The University of Massachusetts at Amherst

Laboratory Health and Safety Manual/Chemical Hygiene Plan

Prepared: ICSC, March 2013

Last Revised: KO and ICSC, May 2022

Last Reviewed: ICSC, May 2022

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Vice Chancellor for Research and Engagement

David Hoagland, Ph.D.
Professor and Chair of Polymer Science and Engineering
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Chapter 1: Introduction

This laboratory health and safety manual/chemical hygiene plan (CHP) has been prepared to comply with federal and commonwealth regulations, best management practices, and university policy to provide a safe working environment that is generally recognized to be free of hazards for employees and students in laboratories, art studios, and associated spaces. Specifically it is designed to communicate the designated administrative responsibilities, accepted general safety guidelines and standards, proper laboratory facilities, safety equipment, emergency procedures, medical surveillance, exposure monitoring, training, and recordkeeping requirements.

The CHP applies to all areas where hazardous material use meets the definition of laboratory use and scale as defined in 29 CFR 1910.1450(b) including, but not limited to, academic laboratories and art studios, hazardous material storage spaces, photographic darkrooms, and hazardous waste satellite accumulation areas (SAA) located in laboratories and studios. For the purposes of this document, a hazardous material is defined as any material which may be classified, or for which there is evidence or knowledge to suggest that it could be classified, as a hazardous chemical under the Hazard Communication Standard (29 CFR 1910.1200). Use of biohazardous materials is covered by the University's Biological Safety Manual (http://ehs.umass.edu/biological-safety-manual). Use of radioactive materials is covered by the University's Radiation Safety Manual (http://ehs.umass.edu/radiation-safety-manual) and work with lasers is covered by the Laser Safety Manual (http://ehs.umass.edu/laser-safety-manual).

Laboratory scale means that manipulations with hazardous materials can be performed by one person. Laboratory use means that operations with hazardous materials are: (1) performed on a laboratory scale, (2) multiple operations with hazardous materials are occurring within the laboratory, or multiple hazardous materials are in use, (3) the operations are not part of a production process, and (4) procedures and equipment are in place to minimize exposure to hazardous materials. In other words, this manual does not cover industrial, maintenance, remediation or quality control operations that involve the use of hazardous materials, or any other large scale uses of hazardous materials.

The use of the words "must" and "shall" in this document indicate required activities. The use of the word "should" indicates recommended practices.

Chapter 2: Roles and Responsibilities

The University is committed to fostering a culture of safety for all faculty, staff, and students. Such a culture enables the fulfillment of the University's mission to create an environment where teaching, learning, service, outreach, discovery, and creativity can flourish. Each of us plays a role in creating this environment. Each individual in the laboratory must be constantly aware of their surroundings and engaging in ongoing risk assessments and experiment planning. While it is important to abide by policies and rules meant to mitigate known risks, it is of even greater importance to be able to assess risks on a situational basis. Safety considerations should be part of all experimental designs from the very start, and should be continually addressed throughout the research process. Principal Investigators (PIs) and Responsible Individuals for laboratories should engage in discussion of safety considerations with their laboratory personnel and encourage discussion amongst their personnel of particular topics when appropriate. Department chairs should provide necessary and appropriate support for PIs to encourage attention to important safety considerations particular to their departments. When each individual is committed to safety, a strong sense of community identity invested in safety will emerge and benefit all.

The Chancellor has delegated to each dean, director, department head/chair, and supervisor the responsibility for safety performance within their respective units. Environmental Health and Safety (EH&S) and the campus safety committees help ensure that campus policies, as well as state and federal mandates, are followed.

Section 1: Administrative Responsibilities

Environmental, Health and Safety (EH&S) is available to provide additional oversight, training, consultation, and technical assistance. Specific responsibilities are outlined below.

Responsibilities of Department Heads / Chairs

- Implement University safety and health policies
- Designate a Department Laboratory Safety Coordinator
- Ensure compliance with existing health and safety policies
- Review and grant approval for laboratory operations that involve particularly hazardous materials or processes
- Review and approve of all procedures and experimental apparatus used in the handling of extremely toxic gases, and gases with a high potential for explosion.
- Ensure hazardous materials are properly disposed of when researchers leave the university

Responsibilities of Research and Teaching Directors (Responsible Individuals: Principal Investigators/Faculty/Instructors/Supervisors)

Principal Investigator (PI) – A Principal Investigator is the primary individual responsible for the preparation, conduct, and administration of a research grant, cooperative agreement, training or public service project, contract, or other sponsored project in compliance with applicable laws and regulations and institutional policy governing the conduct of sponsored research. For purposes stated in this document, the PI is also responsible for ensuring that university health and safety policies are adhered to in their laboratory.

Faculty – are responsible for ensuring that university health and safety policies are adhered to in their laboratory.

Supervisors – are responsible for ensuring that all university health and safety policies are adhered to in their areas.

Responsible Individuals – All PIs, faculty, supervisors, lab directors, or other individuals who are responsible for ensuring that all university health and safety policies are adhered to in the areas they are responsible for.

Responsibilities are to:

- Develop a laboratory specific chemical hygiene plan as described in Chapter 6 section 4 of this document.
- Maintain accurate and up-to-date written research protocols that emphasize safety measures to be taken and personal protective equipment to be worn
- Conduct inspections in their labs to ensure compliance with existing policies. A template for self-assessment is provided in Appendix E of this document. The current platform for lab assessments (i.e., BioRAFT) also enables self-assessments using the same format that EH&S uses.
- Inform all laboratory staff and students under their supervision of the potential hazards associated with laboratory operations, signs and symptoms of exposure to hazardous materials in use, and procedures for dealing with incidents and/or injuries
- Assure that staff, students, and employees under their supervision are trained as required by federal and commonwealth regulations, best management practices, and university policy to provide a safe working environment that is generally recognized to be free of hazards and ensure that all lab personnel are complying with the aforementioned requirements.
- Implement corrective actions for remediation of safety and regulatory issues including when provisions of this document are not being met within the lab
- Ensure the safety of all visitors to the laboratories.
- Supervise the laboratory to ensure that safe practices, personal protective equipment, and engineering controls are employed and used properly
- Instruct laboratory staff on the location and use of safety equipment in the facility
- Ensure that laboratory workers complete and submit forms for obtaining authorization for working with highly hazardous materials or processes
- Ensure that laboratory workers understand how to work safely with chemicals

- Report incidents and any other safety problems to the Department Laboratory Safety Coordinator and EH&S
- Ensure that packages of hazardous materials are sent to the Chemical Environmental Management System (CEMS) for inventory and SDS database entry.
- Ensure laboratory personnel information is kept up to date in CEMS.
- Address EH&S inquiries including requests for Standard Operating Procedures, Chemical Hygiene Plans, or resolving other issues in a timely manner. Failure to address issues in a timely manner will result in escalation including, but not limited to: (1) notifying EH&S leadership and the department chair, (2) notifying the dean of the college, (3) notifying the provost.

Instructors and Teaching Directors – The role of instructors and teaching directors is to ensure that university health and safety policies are adhered to by staff, students, and visitors in teaching laboratories.

Responsibilities are to:

- Maintain accurate and up-to-date written laboratory protocols that emphasize safety measures to be taken and personal protective equipment to be worn
- Inform all laboratory staff and students under his/her supervision of the potential hazards associated with laboratory operations and procedures for dealing with incidents and/or injuries
- Supervise the laboratory to ensure that safe practices, personal protective equipment, and engineering controls are employed
- Report incidents and any other safety problems to the Department Laboratory Safety Coordinator and EH&S

Responsibilities of Department Laboratory Safety Coordinator

- Attend the Department Laboratory Safety Coordinator meetings
- Communicate to faculty and staff members University safety and health policies
- Report safety related incidents and potential safety problems that come to their attention to EH&S
- Specific duties may be assigned by the department

Responsibilities of Employees, Visiting Scholars, Students

This section applies to all graduate and undergraduate students in research laboratories.

- Follow all safety and health procedures in the laboratory as specified in the Laboratory Health and Safety Manual / Chemical Hygiene Plan and by the faculty supervisor or responsible individual
- Attend required health and safety training sessions as described in Chapter 11 of this document.
- Report incidents, unhealthy, and unsafe conditions to the faculty supervisor and EH&S

- Only conduct approved experiments for which there are written protocols in place
- Laboratory personnel are encouraged to notify the faculty supervisor of any pre-existing health conditions that could lead to a serious health situation in the laboratory

Responsibilities of Environmental Health & Safety

- Provide technical guidance on matters of laboratory safety
- Inspect laboratories to ensure compliance with safety and health guidelines and applicable regulations and to assist with remediation of safety issues
- Investigate incidents and recommend action to reduce the potential for recurrence
- Coordinate clean-up operations in the event of chemical spills or other contamination
- Develop and conduct training programs in laboratory safety, including the contents of this document
- Work with state and local officials on matters of codes and enforcement
- Assist laboratory personnel with evaluating, preventing and controlling hazards
- Oversee the adoption and implementation of all University health and safety policies
- Maintain and update the University's Laboratory Health and Safety Manual / Chemical Hygiene Plan
- Conduct chemical environmental / exposure monitoring as needed
- Receive and deliver packages of hazardous materials
- Maintain the chemical inventory system and Safety Data Sheet (SDS) database (CEMS)
- Post door cards for each laboratory that stores or uses hazardous materials

Section 2: Safety Committees

The following UMass/Amherst safety and ethics committees have been established in accordance with state and federal mandates and grant funding agency requirements: Radiation Use Committee (RUC), Institutional Biosafety Committee (IBC), Institutional Animal Care and Use Committee (IACUC), and the Institutional Review Board (IRB). An Institutional Chemical Safety Committee (ICSC) has also been established. The members of these committees are appointed by the Vice Chancellor for Research and Engagement. The responsibility of the committees shall be to establish safety, health, and ethical policies in accordance with federal, state, and local laws and regulations, institutional needs and best management practices, and to evaluate research being conducted on the UMass/Amherst campus for safety, health, and ethical considerations.

IACUC and IRB ensure that research and teaching at UMass Amherst that involves animal (IACUC) and/or human subjects (IRB) is conducted in compliance with state and federal laws pertaining to the health and welfare of the research subjects. These committees may refer research projects brought to them for review to the appropriate safety officer and/or safety committee for environmental health and safety review.

The ICSC is the principal campus committee charged with advising on matters that relate to the safe use of chemicals in the laboratory environment. This includes reviewing and approving guidelines and standard operating procedures (SOPs) and practices for the use of chemicals. The ICSC provides assurance that activities at the UMass/Amherst campus do not present unacceptable risks to the health and safety of faculty, staff, students, visitors, and the local community.

Chapter 3: Hazard Identification and Communication

Recognizing and communicating hazards in the laboratory is the first step in assessing risk. All hazards must be identified by means of appropriate labeling in all laboratories and associated areas. This includes all containers of hazardous materials, unattended processes involving hazardous materials that present a physical or health hazard, and areas where hazardous materials or processes are housed.

Section 1: Container Labeling

All containers of hazardous materials must be appropriately labeled with the contents of the container and the major applicable hazards of the material. This includes containers of hazardous materials provided by the manufacturer of the material (i.e., the primary container) and containers to which virgin materials and mixtures are transferred (i.e., working containers).

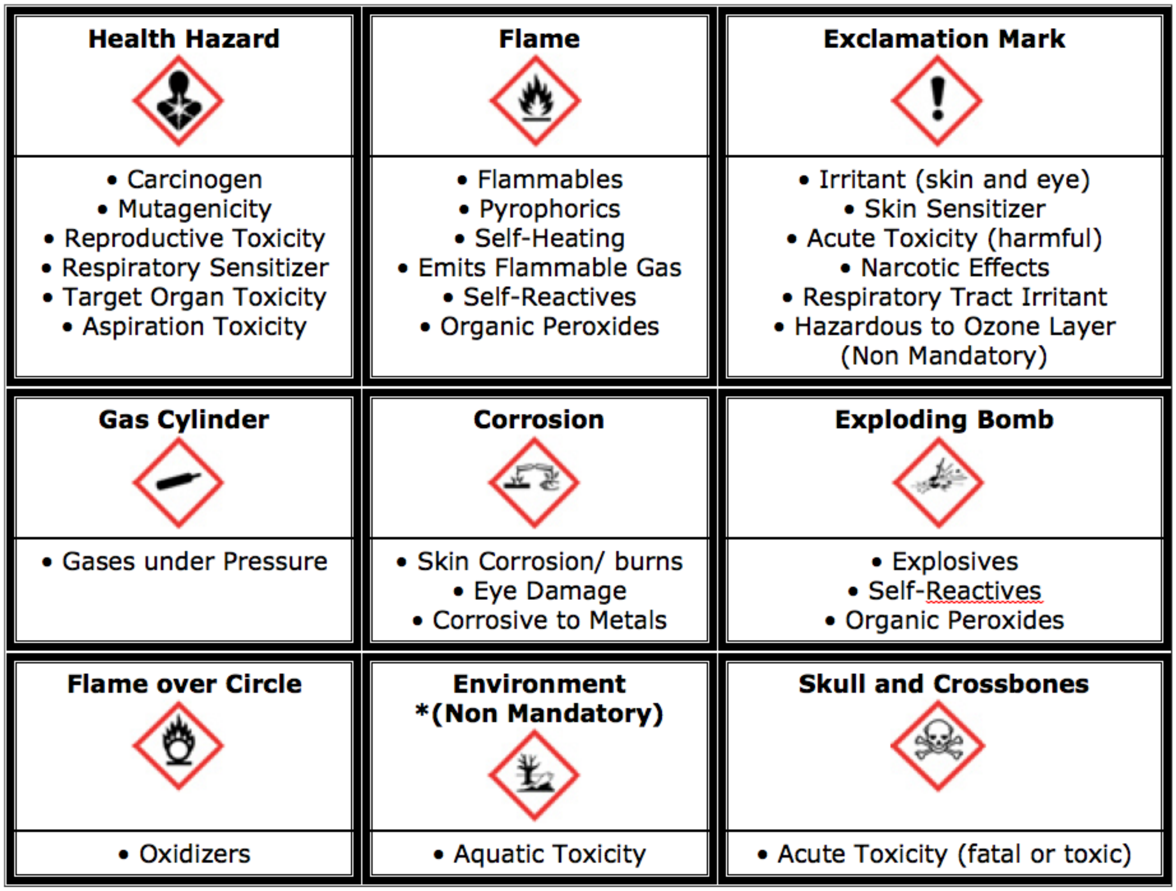
Manufacturer Provided Containers

Containers of hazardous materials provided by the manufacturer that were purchased after December 1, 2015 must comply with the Globally Harmonized System (GHS) labeling requirements detailed in Appendix C of 29 CFR 1910.1200. Namely, each primary container label should contain the following information:

- Product identifier (e.g., generally the name of material)
- Applicable GHS pictograms
- Applicable GHS signal word
- Applicable GHS hazard statements
- Applicable GHS precautionary statements
- Name, address and telephone number of manufacturer or other responsible party

GHS pictograms, along with associated hazard classes, are shown in Figure 1. Qualitative definitions of the GHS hazard classes may be found in Appendix B to this document; more rigorous, quantitative definitions can be found in 29 CFR 1910.1200 appendices A and B.

Figure 1: GHS Pictograms and Associated Hazard Classes



Manufacturer container labels of hazardous materials purchased prior to December 1, 2015 and after March 11, 1994 must minimally comply with the provisions of the 1994 Hazard Communication Standard, and should include:

- Product Identifier (e.g., generally the name of the chemical)
- Hazards associated with the material, including target organ effects
- Name and address of manufacturer or other responsible party

Labels supplied with manufacturer containers must not be destroyed or covered unless the container is emptied. Additionally, when peroxide forming materials are delivered on campus to CEMS (see the procurement section of this document for a description of hazardous material receipt and delivery), they are supplied to individual laboratories with a label that should be placed on the container indicating when they have been, and are due for, peroxide testing (Figure 2). In addition to labels, primary containers are supplied with Safety Data Sheets (SDSs) which further detail the hazards of the material. SDSs are discussed in Section 2 of this chapter.

Figure 2: Peroxide Forming Material Label

Warning! May Form Explosive Peroxides!

Test every 3 months for peroxides and before concentrating. Contact EH&S (413-545-2682) for test strips. Do not open or move bottle if crystals, discoloration, or layering are present. Contact EH&S for assistance and disposal of items giving a positive test.

Date Received..............Opened................

Test Results

Date.......................Pass..........Fail..............

Date.......................Pass..........Fail..............

Date.......................Pass..........Fail..............

Working Containers

When a virgin hazardous material is transferred from a manufacturer container to another container, or when a mixture containing at least one hazardous material is created and stored in a container, the new storage container is referred to as a working container. Working containers must minimally be labeled with the following information:

- The identity of the material (without chemical abbreviations or symbols). Abbreviations may only be used as the sole means of identification if the laboratory or storage area in which the material is to be stored has posted a key for all abbreviations for easy access by emergency response personnel with its location specified on the door card.
- The significant hazards of the material.

The significant hazards may be communicated by means of the GHS system, the NFPA or HMIS systems, or by indicating the hazards with words on the label. Qualitative definitions of the GHS hazard classes may be found in Appendix B to this document; more rigorous, quantitative definitions can be found in 29 CFR 1910.1200 appendices A and B. Some typical physical and health hazards (and very qualitative definitions of these) that may appear on non-GHS labels appropriate for working containers include, but are not limited to the following:

Allergen: May cause allergic reactions

Carcinogen: May cause cancer

Combustible: Will support combustion (i.e., burn)

Corrosive: Destroys tissue or possesses a pH of 11.5 (or greater) or 2 (or less)

Explosive: Releases heat, pressure or gas when exposed to elevated temperature, pressure or shock

Flammable: May ignite very easily at lower temperatures and/or concentrations

Irritant: Inflames tissue

Lachrymator: Vapors may cause eye irritation

Oxidizer: Initiates or promotes combustion in other materials

Pyrophoric: May ignite spontaneously on contact with air

Sensitizer: May cause allergic reactions after repeated exposures

Simple Asphyxiant: Displaces oxygen in an atmosphere to create an asphyxiation hazard

Target Organ Effects: Exposure via a specified route may cause damage to particular organs, tissues or other structures

> **Hepatoxin:** May cause liver damage
>
> **Neurotoxin:** May cause damage to the nervous system
>
> **Nephrotoxin:** May cause damage to the kidneys
>
> **Teratogen:** May cause abnormalities with embryonic or fetal development
>
> **Mutagen:** May cause replication errors in DNA

Hematopoietic agent: May damage hemoglobin and cause oxygen deprivation

Toxic: May be harmful (in some cases, fatal) if exposure via a specified route occurs above a given level

Unstable or Reactive: Vigorously polymerizes, decomposes or self-reacts under conditions of shock or elevated pressure or temperature

Water-reactive: Chemically reacts with water to form a gas that is either flammable and/or a health hazard

Health and physical hazards may also be summarized on labels by means of the NFPA diamond (as described in NFPA 704), the HMIS bar label (as described by the American Coatings Association) or any other appropriate means. Individuals working in a laboratory or laboratory support areas must be trained on the elements of the GHS system and any other hazard communication systems they are likely to encounter during the course of their work. A basic introduction is given in the EH&S Lab Safety classroom and online trainings.

Newly Synthesized Materials

Any newly synthesized material or byproduct of a reaction that meets the definition of hazardous material as described in Appendix A of this document must be labeled as such, and the hazards of the material must be communicated to the individuals working with the material. For truly unique materials, data on hazards may be scarce or non-existent. Testing of new materials to characterize hazards is not required, however, a thorough literature review is required and the process must be documented. Appendix C of this document (Hazard Assessment for Newly Synthesized Materials) should be used to document this process. Copies should be kept on file in the laboratory and provided to EH&S. If the material is to be sent offsite for testing or other use, labeling must be in full compliance with 29 CFR 1910.1200 including preparation of a Safety Data Sheet (SDSs, See section 2 of this chapter for a discussion of SDSs).

Section 2: Safety Data Sheets (SDSs)

Safety Data Sheets (SDSs) are supplied to end users by manufacturers and suppliers of hazardous materials each time a hazardous material is sold to an end user. SDSs are standardized 16 section documents that detail the hazards, control measures, emergency response, waste disposal and other important information associated with a particular hazardous material. All hazardous materials that are sent to the University after December 1, 2015 must have an available GHS compliant SDS that is in the format described in 29 CFR 1910.1200 Appendix D. This may be provided as a paper or electronic copy, or it may be available online through the manufacturer's/supplier's website. Hazardous materials that were purchased before this date have a similar, though less thorough and standardized, document called a Material Safety Data Sheet (MSDS) that is an older version of the SDS. The University maintains an electronic database of all M/SDSs for hazardous materials in laboratory and associated areas. The SDS database is part of the CEMS inventory management systems, and may be accessed from the Environmental, Health and Safety homepage, or directly at https://cems.unh.edu/umass/CEMS/Dashboard. An account is not necessary to access SDSs. CEMS is updated daily with the most current SDSs available for the hazardous materials currently in the inventory system. In the event of a power failure or internet outage, please call EH&S at 413-545-2682 for immediate assistance with locating SDSs. Environmental Health and Safety will include training covering the basic information provided in SDSs, the structure of these documents as specified in 29 CFR 1910.1200 Appendix D, and how to access these documents in CEMS.

The first time a new hazardous material is to be used in a laboratory, the SDS (along with other resources describing health and physical hazards, chemical and physical properties, etc.) should be thoroughly reviewed and understood by laboratory personnel who will be using the material. Environmental Health and Safety is happy to provide assistance in locating appropriate references.

Section 3: Process and Equipment Labeling

Laboratories typically have processes occurring that are hazardous either because the process uses a hazardous material or because the process itself creates physical or health hazards. All processes and equipment that are hazardous must be appropriately labeled to communicate the relevant hazards. Examples of appropriate hazard labeling include, but are not limited to, the following:

- Unattended hazardous operations must be prominently labeled with the nature of the experiment (including the identity and hazards of any hazardous materials present), the contact information (i.e., name and phone number) of a responsible party, and the time at which they will return
- Refrigerators, freezers, microwaves and other consumer appliances used with hazardous materials must be labeled as “Chemical Use Only-No Food Allowed”
- Consumer foodstuffs such as sugar, aspirin, food coloring, etc. that are used in laboratories must be labeled as “Laboratory Use Only-Not For Human Consumption”
- Lock-out/tag-out must be used for maintenance of equipment capable of discharging electricity. See the University’s policy: https://ehs.umass.edu/hazardous-energy-control-policy-lock-outtag-out.
- Designated areas for highly hazardous operations
- Equipment which can pose specific hazards while in operation (e.g., the magnetic field of an NMR, which can interfere with pacemakers).
- Allergen warning signs in animal care facilities

Section 4: Laboratory Labeling and Chemical Safety Levels

All laboratories are required to have an up-to-date door card (Figure 3) indicating the overall hazards of the laboratory and current contact information for the Principal Investigator (PI), or Responsible Individual for the laboratory, and lab personnel. In the event of an incident, chemical spill, fire or personal injury, assistance from a person familiar with the laboratory may be requested. Doors cards are created by the CEMS system (see chapter 8 section 1 for information on CEMS) and are primarily meant to aid emergency responders. For this reason, door cards indicate general hazards by means of the NFPA diamond where 4 indicates the most severe hazard and 0 indicates the least (note this is the opposite of the GHS labeling system’s numbered categories within hazard classes). Doorcards are updated regularly by Environmental Health and Safety. PIs, or Responsible Individuals for the lab, are responsible for notifying EH&S of lab personnel changes by updating this information in the CEMS system (see chapter 8 section 1 for information on CEMS). EH&S should be consulted about other door postings and signs that may be required (e.g., radioactive materials, biohazards).

Figure 3: Example of CEMS Doorcard

Chapter 4: Risk Assessment and Hazard Mitigation

As discussed in the previous section, risk and hazard are not identical. Risk is the combination of hazards and the probability that those hazards will lead to negative events. Thus, hazards give rise to risk, as do processes that enable the hazard to produce a negative outcome. As such, it is important to recognize all hazards and the processes in which these hazards are used and mitigate all resulting risks in so far as possible.

Risk assessments are useful tools for uncovering hidden hazards and risks, and should be conducted for all new procedures before the procedure is initiated. Risk assessments seek to identify all hazards associated with a planned procedure, and remove or mitigate the risks created by those hazards, or otherwise change the procedure, to simultaneously accomplish the goals of the experiment and ensure the health and safety of the researchers performing the experiment. Conducting a risk assessment can be daunting, even for individuals with years of laboratory experience, because there can be many types of hazards, not all of which are immediately obvious. Probabilities of negative outcomes can also be difficult to discern especially for inexperienced lab personnel. There are also many different ways to conduct a risk assessment, and certain approaches are better for some situations than others. Therefore, a prescriptive, "check list" type of approach is not necessarily desirable. The key feature of any good risk assessment is that it uncovers as many sources of potential hazards as possible, thereby effectively eliminating unrecognized hazards. Good risk assessments should also prioritize hazards and risks based on severity and probability of occurrence, and should most definitely eliminate all risks and hazards that are simultaneously high severity and high probability of occurrence. Contingency plans should be in place and communicated to all relevant parties in the event that something does go wrong.

Risk assessments should follow the principles of **RAMP**:

1. ***Recognize*** all hazards.
2. ***Assess*** the risks of those hazards.
3. ***Minimize*** the risks by mitigating hazards.
4. ***Prepare*** for emergencies.

Below is a very broad and general, but by no means all inclusive, series of questions that one might use to apply RAMP to a particular process.

1. **What is the goal of the experiment you wish to perform?** This is important to keep in mind as you go through the process of assigning hazards and assessing risk. Obviously, any modifications made to a procedure will still have to achieve the goals of the experiment.

2. **Identify all equipment, chemicals, biological organisms and other materials associated with the planned procedure.** A list might be helpful.

3. **Attempt to identify any hazards associated with the use of any of the items on the list, or the circumstances of the procedure.** This is the really difficult part where things can be overlooked. It is a good idea to have multiple people review this area, particularly the PI and

more experienced lab personnel. Their laboratory experience will enable them to recognize potential hazards that less experienced researchers might not be aware of. Here are some questions that might be helpful to guide you through this process.

a. **What apparatus is to be used, and what are the hazards?** For example, glassware containing a vacuum or higher than atmospheric pressure could implode or explode, respectively. Electronic instrumentation might present an electrical hazard if it is dismantled while plugged in or without discharging capacitors. Hoses can pop off of reflux condensers due to changes in water pressure or unsecure connections.

b. **What chemicals are to be used?** Look at the SDSs for these materials, and some of the other sources of information listed in Appendix D.

What are the health hazards of the material (*e.g.,* toxic, carcinogen, corrosive, etc.) and what are its routes of entry (*e.g.,* inhalation, skin absorption, etc.)?

What are the exposure limits to the materials?

What are the symptoms of exposure to the material (*e.g.,* noticeable odor, headaches or nausea)?

Are any of the chemicals highly reactive (*e.g.,* pyrophorics, shock sensitive materials, oxidizers, water-reactives, strongly incompatible with other materials, etc.)?

Do the materials degrade in storage to form something more hazardous (*e.g.,* peroxide forming materials, etc.)?

c. **What biological organisms are to be used?**

Are any of the organisms considered to be infectious or transgenic?

What are the potential routes of exposure?

d. **Are radioactive materials involved?**

e. **Are sharps used?**

f. **Is there a potential for exposure to harmful levels of electromagnetic radiation (*e.g.,* lasers, flash lamps, etc.)?**

g. **Are there temperature extremes involved (*e.g.,* cryogenics or heat)?**

h. **Are there synergistic hazards, *i.e.*, hazards resulting from the presence and interaction of two or more items?**

For example, is there a potential to form any highly reactive or otherwise hazardous byproducts during a reaction?

4. **What is the level of severity of each hazard, and the probability that it will create a problem within the given procedure?** Any items which create a risk that is high severity and

high probability of occurrence must be removed or mitigated in the next step. Ideally, we would like all risk to be low severity and low probability of occurrence.

5. **Plan to remove or mitigate the hazards using substitutions of less hazardous items and procedures, engineering controls, administrative controls and personal protective equipment.** The list should always be applied in the order above with substitutions of less hazardous items or practices being tried first and personal protective equipment being the last line of defense against hazards. These items are discussed in more detail in later chapters of this document. It will not always be possible to use all four options, but it is frequently possible to use more than one option to remove or reduce risk. Substitution might include changing the solvent of a reaction (e.g., using water instead of a toxic organic solvent). Engineering controls eliminate or greatly reduce the hazard through use of mechanical equipment or other technologies that contain the hazard. An example is the chemical fume hood or biological safety cabinet. Administrative controls reduce individual exposure to hazards by limiting individual contact with the hazard through work practices. Examples include many general and standard operating procedures, like keeping the lab tidy to minimize hazards, not recapping needles prior to disposal and not eating or drinking in the lab. Use of personal protective equipment (PPE), like goggles, gloves and lab coats, is the last line of defense, and is generally used in conjunction with other methods. In all cases where regulatory exposure limits and thresholds (e.g., PELs, TLVs, STELs, RELs etc.) exist for given materials, these must be observed.

6. **Ensure that your modified procedure still meets the goals of your experiment and eliminates all high risk, high probability situations.** For example, if you have changed materials or equipment, ensure that the new materials and equipment do not create new, unrecognized hazards. You should also have plans in place for emergencies, such as equipment failure, loss of power or a chemical spill.

The above are general principles to be used for risk assessments. More structured approaches are available. See for example the extensive materials available from the American Chemical Society:
https://www.acs.org/content/acs/en/about/governance/committees/chemicalsafety/hazard-assessment/fundamentals/risk-assessment.html (and links therein).

Chapter 5: Engineering Controls

Engineering controls are pieces of equipment, or other technologies, that can be used to mitigate physical and health hazards. After substitutions of less hazardous items in a procedure (which is not always possible), engineering controls are the next line of defense. Examples common in a laboratory include, but are not limited to, chemical fume hoods, the rate of air exchange in the laboratory, glove boxes, glove bags, snorkel exhausts, blast shields, guards on moving pieces of equipment, etc. Note that biological safety cabinets (BSCs) are not appropriate for work with hazardous chemical materials unless the exhaust is hard ducted to the outside of the building.

Section 1: Ventilation

One of the greatest possible sources of exposure to hazardous materials is through airborne exposure. General room ventilation does not usually provide adequate protection against hazardous gases, vapors, and aerosols. For this reason, many different types of engineering controls exist to capture airborne contaminants with varying degrees of efficiency. ***All work with pyrophorics and significant quantities of highly corrosive, flammable, malodorous, toxic, or other dangerous materials must be conducted in a properly operating chemical hood, gas cabinet, or glovebox as appropriate.***

Generally, the following guidelines should be used to determine under what conditions and what type of engineering control must be used to protect laboratory personnel from inhalation hazards.

1. Appropriate methods should be used to ensure that exposures to all materials are below regulatory or recommended thresholds (i.e., PEL, STEL, TLV, etc.) when these exist.

2. **For Pyrophorics, Gases or for Processes Evolving Gases**: A chemical fume hood or gas cabinet (exhausted to the outside of the building) must be used at all times for storage and use of any hazardous material or mixture that exists as a gas and may be classified under GHS as any of the following:

    a. Acute Toxicity, Inhalation Categories 1, 2, or 3
    b. Specific Target Organ Effect (Single Exposure or Repeated) Categories 1 or 2 through inhalation route of exposure
    c. Sensitization-Respiratory Categories 1A and 1B
    d. Germ Cell Mutagenicity Categories 1A and 1B through an inhalation route of exposure
    e. Carcinogenicity Categories 1A and 1B through an inhalation route of exposure
    f. Toxic To Reproduction Categories 1A and 1B through an inhalation route of exposure
    g. Pyrophoric liquid or solid
    h. Flammable gas with the hazard statement: Ignites spontaneously on contact with air

Procedures that are likely to evolve a gas that can be thus classified must also be performed in chemical fume hoods.

3. **For Solids and Liquids Not Evolving a Gas**: A chemical fume hood, glove bag, or glove box must be used for any hazardous material or mixture that exists as a solid or liquid and is used in such a way that generation of significant aerosols, mists, vapors, splashes or other airborne particulates is likely and that may be classified under GHS as any of the following:

    a. Acute Toxicity, Inhalation Categories 1, 2, or 3
    b. Specific Target Organ Toxicity Effect (Single Exposure or Repeated) Categories 1 or 2 through inhalation route exposure
    c. Sensitization-Respiratory Categories 1A and 1B
    d. Germ Cell Mutagenicity Categories 1A and 1B through an inhalation route of exposure
    e. Carcinogenicity Categories 1A and 1B through an inhalation route of exposure
    f. Toxic To Reproduction Categories 1A and 1B through an inhalation route of exposure

Gloveboxes may also be used for the storage and use of pyrophoric liquids and solids, but should not be used for the sole means of containment of pyrophoric gases unless it is specifically designed for that purpose. In special situations, vacuum systems are acceptable if approved by EH&S. Ductless chemical hoods are only acceptable for specific applications and when approved by EH&S. When it is not possible to meet the above requirements, EH&S, the faculty member, and the department head/chair must evaluate hazards and do a risk assessment together to determine if work can be conducted safely. (See the Administrative Controls section of this chapter). EH&S is also happy to answer any questions regarding selection of appropriate ventilation for a particular process.

Chemical Fume Hoods

Chemical fume hoods afford a high degree of containment of airborne contaminants when used properly. They also provide a barrier for splashes and impact. As such, they are generally the best choice of ventilation protection when available.

Chemical hoods are checked annually for proper air flow by Physical Plant and/or EH&S. The velocity of the air at the face of the hood is measured with the sash at the hood's appropriate working height, typically 16-18 inches opening. The resulting air flow is posted on a sticker attached to the lower right-hand corner of the sash. On most hoods, green arrows are placed 16-18 inches from the deck of the hood where air flows will meet the minimum acceptable face velocity. EH&S recommends that researchers work with the sash lowered to the "green arrow level" to also protect themselves from potential splashes, explosions, or other dangerous reactions. Researchers should have the sash lowered as much as possible when conducting experiments and completely close the hood sash when not actively working in the hood.

Hoods that do not meet the minimum exhaust requirements during Physical Plant or EH&S inspections are posted "**Warning Do Not Use**." Physical Plant is then notified to repair the hoods. After repairs have been made, hoods will be retested to verify their proper operation. If you ever notice that a fume hood is not operating properly, immediately label the hood and notify Physical Plant (413-545-6401).

There are several different types of chemical fume hoods available at the University:

Variable air volume hoods (VAV) maintain a constant face velocity at different sash heights. VAV hoods also provide significant energy saving by reducing the flow rate when the hood is closed.

Constant air volume hoods (CAV) increase or decrease the airflow/face velocity into the hood depending on the sash opening (e.g., closing the sash would increase the air face velocity; opening the sash would decrease the face velocity). *Work with the sash at the green arrow to ensure the proper face velocity is achieved.*

Low flow or High performance chemical hoods need to pass the NIH-modified ASHRAE 110 standard (when newly installed) for a set face velocity that is approved by EH&S.. These hoods are only appropriate for specific applications, and all use of high performance or low flow hoods must be reviewed and approved by EH&S.These hoods tend to be deeper than the traditional laboratory chemical hoods and have internal or external airfoil and or movable baffles. Due to their design differences from traditional chemical hoods, laboratory personnel need to be made aware of their proper use (i.e., proper sash height to reduce exposures to hazardous chemicals.) Contact EH&S for more information on the use of these hoods.

Procedures for Proper Use of Chemical Hoods

- Before using a hood, make sure air is entering the hood and the hood is functioning properly. Check the air flow controller to ensure face velocity is correct (typically 80-100 fpm) at the appropriate sash height.
- Report any problems with chemical hood operations to Physical Plant at 413-545-6401 for repair and to EH&S at 413-545-2682 for follow-up.
- Do not block baffle openings or place bulky items in the hood that will prevent air from entering the baffle opening.
- Avoid opening and closing the hood sash rapidly, and avoid swift arm movement in front of or inside the chemical hood.
- Conduct work at least six inches in from the edge of the hood.
- Lower the sash to at least the "green arrow settings" to protect yourself from dangerous reactions and/or chemical splashes.
- Keep the hood clean and uncluttered. Wipe up spills immediately.
- Be aware that drafts from open windows, open doors, fans, air conditioners, or high traffic walkways may interfere with normal hood operation.
- Do not attach "Kim-wipes" or other similar material to the hood sash.
- Keep the hood sash closed whenever the hood is not actively in use or is unattended to conserve energy.
- Concentrated and/or hot solutions of perchloric acid should only be used in approved perchloric acid fume hoods (See the policy on Perchloric Acid use on the EH&S website.)

Chemical Hood Monitors and Alarms

All chemical hoods at UMass should have a hood monitor installed near the face of the hood, usually on the upper right corner. The hood monitor indicates the air-flow into the hood at a certain hood sash opening. It could be a digital readout or just an indicator light of high, low, and proper flow (green). *Notice the air flow monitor before doing work in the hood.* The monitor should typically indicate 80 or 100 fpm and will go into alarm (audio/visual) if the flow is within ±20% at the appropriate sash opening. Certain hoods approved by EH&S may have higher or lower face velocities. If you have questions about the appropriate face velocity for a fume hood, please contact EH&S. If the hood alarm sounds, and does not stop when the sash is fully closed, notify Physical Plant (413-545-6401). Post a sign on the hood reading "**Warning Do Not Use**". <u>Do not mute the alarm and continue working in the hood. Do not disable alarms.</u> Do not use the hood until repairs have been made and the sign has been removed by an appropriate person.

Chemical Hood Purge Button

In some buildings the hood monitor contains a purge button. When pushed, this button will open the pneumatic valve to allow a very large opening in the ductwork for maximum hood exhaust (e.g., in the event of a spill). Turn off the purge button about 1-2 hours after activating as a result of a spill. *Do not work with the purge button on.*

Perchloric Acid Hoods

Regular chemical hoods must never be used for hot or concentrated perchloric acid. Special perchloric acid hoods must be used. When perchloric acid is heated above ambient temperature, vapor is formed which can condense in the ductwork and form explosive perchlorates. The perchloric acid hood and ductwork must be equipped with a water wash down system, which needs to be operated after each use of perchloric acid. The hood must be labeled clearly and used only for perchloric acid or other mineral acids such as nitric, hydrochloric, and hydrofluoric. ***No organic solvents should be stored or used in a perchloric acid hood.*** Contact EH&S (413-545-2682) if your work requires the use of organic solvents with perchloric acid and for locations of perchloric acid hoods on campus and training for their proper use.

Glove Boxes

Glove boxes can be used for work with many different types of highly hazardous substances, but are particularly useful for liquid and solid pyrophorics and other air and water sensitive materials. Glove boxes are usually operated under positive pressure with respective to the surrounding environment and provide an inert atmosphere. Some remove only oxygen and not water, so it is important to understand the applications for which a particular glove box is designed prior to use. Users should be trained on the operation of these units, including the limitations of the unit, prior to work.

Glove boxes equipped with HEPA-filters prevent particulates – including toxic dust, bacteria, and viruses -- from escaping into the laboratory. Some glove boxes are also equipped with activated carbon filters that remove harmful gases and vapors from the exhaust air. Glove boxes should be tested for leaks and glove integrity before each use. A method to monitor the integrity of the system, such oxygen and water sensors, is required. Note that an exposed filament from an incandescent bulb is not an appropriate oxygen monitor. Spills (of both solids and liquids) within glove boxes need to be cleaned immediately. The use of sharps should be kept to a minimum.

Gas Cabinets

Cylinders of highly toxic, toxic, and/or pyrophoric gases, as defined in the fire (527CMR) and building (780CMR) codes, must be stored only in an approved gas storage cabinet. In a gas cabinet, hazardous gases can be vented through a scrubbing system that can remove hazardous components from the exhaust. In addition, gas cabinets can be equipped with monitoring devices and alarm systems that sense hazardous conditions, warn employees of a malfunction, and automatically shut-off the gas flow. For small quantities of highly toxic and toxic gases in lecture bottles, it may be acceptable to use and store the gas in a chemical fume hood if approved by EH&S.

Biological Safety Cabinets (BSCs)

A biological safety cabinet (BSC) is the primary barrier of protection for individuals working with biohazardous materials. Laboratory procedures that could create airborne biohazards should always be performed in a BSC as it protects the samples, as well as the laboratory workers and the environment, from aerosols or droplets that could spread biohazardous material. The common element to all classes of biological safety cabinets is the high efficiency particulate air (HEPA) filter. This filter removes particles with aerodynamic diameters of 0.3 microns (i.e., the most penetrating particle size) with an efficiency of 99.97 percent. Particles with aerodynamic diameters both smaller and larger than 0.3 microns are removed with nearly 100 percent efficiency. However, HEPA filters do not collect/remove vapors or gases.

To ensure safety, BSCs must be used correctly with good microbiological techniques and be in proper mechanical working order. Cabinets should be certified for performance upon installation using the National Sanitation Foundation (NSF) Standard 49, Section 6. Recertification should be conducted annually or more frequently if the cabinet is moved or if a performance problem is suspected. The University has contracts with several companies to service and certify BSCs. Information on certification is available from the Biosafety Officer at EH&S.

The following general rules apply to biological safety cabinets at UMass Amherst:

- BSCs are certified annually by an outside company

- BSC surfaces must be decontaminated frequently and after work is complete
- Gas lines are prohibited in newly-installed BSCs
- Open flames are not recommended inside BSCs
- Toxic and volatile chemicals are prohibited inside Class II, Type A BSCs (i.e., BSCs which do not have exhaust hard ducted to the outside of the building). Small quantities of these materials may be used in Class II, Type A&B BSCs.
- Ultraviolet lights are not recommended for use in BSCs. If present, UV lights must never be used when active work is occurring in the BSC.

Horizontal Laminar Flow Hoods (Clean Benches)

Horizontal laminar flow "clean benches" are devices that look similar to biosafety cabinets, but only protect the product from contamination. These devices provide a very clean environment, but must be used only for the manipulation of *non-hazardous* materials. Since the operator sits in the downstream exhaust from the clean bench, this equipment must never be used for the handling of hazardous or infectious materials. Contact EH&S for yearly testing by an outside contractor for laminar flow benches.

Elephant Trunks, Snorkels and Canopy Exhausts

An 'elephant trunk' or 'snorkel' is a duct or hose connected to an exhaust system. In the case of a canopy exhaust, a canopy is attached to the end of such a duct. It is often used to capture small amounts of contaminants at the source such as small scale weighing, milling, alcohol swabbing, or for instruments such as gas chromatographs, mass spectrometers, flame, furnace and inductively coupled plasma atomic absorption spectrometers.

Do not use elephant trunks for chemical reaction work involving highly hazardous materials or significant quantities of other hazardous materials! A working chemical hood should be used for those operations.

The face velocity of a snorkel is usually 150-200 FPM but drops off sharply as distance from the intake increases. Therefore, keep the contaminant source no more than one duct diameter away to ensure efficient capture.

Slot Hood

Slot hoods are local exhaust ventilation hoods specially designed to capture contaminants generated with a specific rate, distance in front of the hood, and release velocity for specific ambient flow. Slot hoods have been used on the UMass campus to capture odor releases from hazardous waste stored in trays. To be effective, the slot hood must be designed by a ventilation engineer taking into consideration the proper geometry, flow rate, and static pressure of the hood. Consult EH&S for the proper use of slot hoods.

Vacuum Systems

In some cases, such as ablation chambers, hazardous materials are adequately contained within a full vacuum system, or a system that is under a negative pressure differential with respect to the surrounding lab space. The hazardous materials contained within these units usually require extremely high temperatures and/or low pressures to remain in a gaseous state, and thus, do not present a high level of airborne exposure risk. Vacuum systems that are the sole means of containment for materials that are volatile at room temperature and pressure require review by EH&S prior to use.

Section 2: Equipment

Many of the engineering controls typically used in lab spaces are meant to mitigate against airborne exposure to hazardous materials. Many of the engineering controls designed for these ventilation purposes also serve to provide a barrier to contact with hazardous materials or conditions including splash and impact. The other common engineering controls used in lab spaces usually seek to mitigate these non-ventilation related hazards.

Guards

Guards are typically used to prevent contact with hazardous items like moving parts of machinery or to prevent falls from elevated areas. All equipment that contains moving parts capable of causing injury must have guards in place to prevent contact with the moving parts. This includes all belt pumps. See the Shop Protection Program for more information: https://ehs.umass.edu/shop-safety-program. If laboratory personnel are working in areas that are elevated more than six feet from the floor, the area must have guard rails in place or a fall protection program must be implemented. Contact EH&S for assistance with development of a fall protection program.

Blast Shields

The sash of laboratory chemical fume hoods provides some measure of protection from impact, however, in the case of work with highly energetic or potentially explosive materials or processes, additional protection may be necessary. Blast shields are designed to afford such protection and are placed between the hazardous process or material and the worker. **If you are engaged in any work which requires a blast shield, prior approval is required from EH&S and the Institutional Chemical Safety Committee.**

Chapter 6: Administrative Practices

Administrative practices should be used to mitigate hazards that have not been adequately removed by substitutions or by the use of engineering controls. Administrative practices are policies or other practices that limit exposure of laboratory personnel to hazardous materials. Examples include, but are not limited to, not eating in the laboratory, and using secondary containment for transporting chemicals. The University has many such policies and general practices. These are listed in the section that follows of this document. Individual laboratories will also have standard operating procedures (SOPs) for laboratory specific items.

Section 1: General Laboratory Safety Procedures

The following are general laboratory safety policies that must be followed at UMass.

- Always wear appropriate clothing in the laboratory for example, long pants, socks, closed toed shoes, and do not wear shorts or miniskirts, high heeled shoes, open-toed shoes, or sandals with woven material. Confine long hair, jewelry and loose clothing.
- No eating, smoking, drinking, preparing food, or applying cosmetics in the laboratory. No food or drink, even sealed in closed containers, should be present in any laboratory containing chemicals. Food and drink must not be stored in laboratory refrigerators or freezers.
- Earbuds or headphones such as those connected to cell phones and iPods™ (MP3 players) must not be used in the laboratory.
- Tasting of hazardous materials is prohibited.
- All laboratory equipment, such as glassware, should be inspected prior to use to identify conditions that could produce failure. Sheathing should be used to contain shrapnel from items which could implode or explode (such as dewars) when appropriate and possible.
- Dustpans and brooms (or other mechanical devices) must be used to clean up broken glass. Do not use your hands. Use of plasticware is encouraged when possible. Glass must be disposed of in glass waste boxes (available on request from CEMS).
- Containers of all liquid or solid materials must be covered (*i.e.*, capped, covered with parafilm or a watchglass, have a reflux condenser, etc.) when not in use. Prepared materials or reactions which evolve gases should have loose fitting covers, or some other form of pressure outlet, and be in a fume hood until gas evolution has ceased. Gas trapping techniques should be used for significant quantities of hazardous gases when possible (*e.g.,* bubbling HCl through a sodium hydroxide solution). Venting directions for gas evolving materials (*e.g.,* fuming nitric acid) purchased through manufacturers must be strictly obeyed.
- The use of oil baths for heating is discouraged. If oil baths must be used to maintain a constant temperature throughout the medium, only silicone oil with a high flash point may be used. Mineral oil and pump oil are not permitted. The oil in baths must be changed if it becomes contaminated or shows signs of discoloration

- Never return unused materials to the stock bottle once dispensed. Trace contamination can lead to potentially disastrous reactions.
- Electrical equipment with frayed cords or exposed wires must not be used.
- Mercury thermometers should not be used unless they are absolutely necessary for purposes of accuracy. The use of mercury containing apparatus for other purposes should be minimized in so far as possible.
- Always use eye protection when you, or others nearby, are working with chemicals or performing processes that could unexpectedly release high velocity objects ('projectiles'). Unless allowed by posted signs, eye protection is always required. Eye protection is discussed in detail in the next chapter of this document.
- Wear chemical-resistant personal protective equipment (e.g., lab coats, gloves) when you or others nearby are working with chemicals or chemical-containing apparatuses. Gloves and skin protection are discussed in detail in the next chapter of this document.
- **Never work alone at any time in the laboratory when conducting potentially hazardous operations.** When hazardous operations are planned, arrangements should be made to have another individual present.
    - A hazardous operation can involve physical (e.g., heating, cooling, mixing, distilling, compressing, and pressurizing) or chemical processes (e.g., oxidation, reduction, and reaction involving one or more substances that present a threat to health).
    - An operation can include, but is not limited to, preparation, separation, combination, purification, or other action that causes a change in state, energy content, or chemical composition.
    - A chemical process that involves a combustible or flammable liquid, combustible or flammable solid; compressed gas; radioactive, cryogenic, explosive, or flammable gas; or organic peroxide, oxidizer, pyrophoric, or unstable (reactive) or water-reactive material is inherently hazardous.
    - Any process that uses a compound that is a hazard to health is itself hazardous. A compound is a health hazard if there is statistically significant evidence that acute or chronic health effects can occur in exposed persons, a definition that includes BL-2, and above, biological organisms; biological toxins; and chemicals that are toxic, highly toxic, or corrosive.
    - As general advice, any activity in an academic laboratory or workshop, other than reading instrument values or writing these values into a lab notebook, can potentially be considered hazardous. Even when individuals are not undertaking a hazardous operation, they should evaluate whether nearby operations are hazardous. For example, working alone in a shared hood should be avoided if there is any possibility another hood operation is hazardous.
    - A remote buddy system may be used for activities that have been determined to be low risk (i.e., low probability of occurrence and low severity consequences in the event of a negative outcome) by the PI based on the provisions and requirements of this chemical hygiene plan in consultation with EH&S if needed or requested. Please note that it is preferable from a safety standpoint to have two people present in the lab during operations whenever this is possible. Examples of low risk operations include, but are not limited to:

    - Monitoring the temperature of refrigerators and freezers
    - Filling a small dewar with an inert cryogenic liquid while using appropriate technique and personal protective equipment
    - Changing inert gas cylinders on equipment

  When low risk operations must be conducted by only one individual, someone outside of the lab needs to be able to monitor the individual in the lab to ensure they are safe and that help can be provided in the event that the individual cannot call for help on their own. The monitoring person, or buddy, must have completed EH&S lab safety training, and must be familiar with the process the person in the lab is performing. Acceptable methods of monitoring include, but are not limited to:

    - Checking-In: Let your buddy know when you will be in the lab and for what duration. Check-in with the person via text, phone, or other means (apps and group communication tools) when the time period has ended to ensure the individual is safe. For operations that require extended time in the lab, check-in in 15 minute intervals. If it is possible to coordinate essential operation activities in neighboring labs, consider physical check-ins (while ensuring appropriate social distancing is maintained).
    - Or Video and sound monitoring: Use cameras and microphones to monitor the individual in the lab. Laptops, phones, and tablets equipped with Zoom or Facetime are a good options. Note that it is illegal to record audio without the recorded person's knowledge or consent in Massachusetts.

  If you have questions about buddy systems or what types of activities a buddy system is appropriate for, please contact EH&S (askehs@umass.edu).

- Access to eyewashes, safety showers, exits, fire extinguishers, and electrical panels must not be obstructed. An area of three feet clearance is required around each.
- Always use mechanical pipetting aids. Pipetting by mouth is prohibited.
- A trapping device or collection/overflow flask must be used to protect the vacuum system. In addition, an inline HEPA filter must be used when manipulating biohazardous materials.
- Keep work areas clean and uncluttered at all times. Messy bench tops, fume hoods, and overcrowded chemical storage can lead to accidents.
- Corridors and aisles must not be obstructed. Make sure primary and secondary means of egress are available.
- Chemical freezers must be defrosted on a regular basis as needed. The frequency should be often enough to prevent significant quantities of ice buildup; annually is generally sufficient, though exact frequency depends on usage and may be more or less often. Ice and water from defrosting must be collected in bins, trays, with absorbent material or by other appropriate means. Ice and water that are grossly contaminated with hazardous materials should be referred for hazardous waste disposal.
- Do not leave experiments involving highly hazardous chemicals or processes unattended even for a brief period. When less hazardous experiments are to be unattended, these must be prominently labeled with the nature of the experiment

(including the identity and hazards of any hazardous materials present), the contact information (i.e., name and phone number) of a responsible party, and the time at which they will return

- Compressed gas cylinders may only be transported with the cap in place and by using a cart with a chain (or heavy-duty fabric belt) to keep the cylinder in place.
  - Gas cylinders must be firmly affixed to walls or benches with a chain or strap, secured with floor stands, or directly attached to an approved gas cylinder cart, during storage and use.
  - Gas cylinders that are not in use (*i.e.*, do not have a regulator attached) must have the cap in place.
- Wearing gloves and lab coats outside the lab must be avoided.
  - Package the material inside a closed secondary container so it may be handled without gloves if there is a need to transport hazardous materials.
  - Gloves should **never** come in contact with door handles, elevator buttons, telephones, lavatory faucets, vending machines, bottled-water dispensers, ice-making machines, personal items or other surfaces outside the laboratory.
  - For the sake of safety, appearances, and courtesy, avoid wearing contaminated, stained, or potentially contaminated lab coats and other research clothing and equipment outside of the laboratory.
- Secondary containers must be used for the transport of hazardous materials between rooms, floors, buildings, etc. (*e.g.,* closed bottle carriers or a bin and a cart with side rails).
- The use of sharps (needles, razor blades, cannulae, etc.) is discouraged. If sharps must be used, the following must be done.
  - Sharps must be disposed of in appropriate, puncture resistant receptacles designed for this purpose in compliance with 105 CMR 480. Sharps containers are available on request from the CEMS system. CEMS should also be used to request pickup of full containers.
  - Needles must not be bent, broken, sheared, recapped, removed from disposable syringes, or otherwise manipulated by hand prior to disposal.
  - Reusable sharps must be stored with all sharp edges covered (*e.g.* in block of Styrofoam, or similar material).
  - Contaminated reusable sharps must be decontaminated (chemically or thermally, as appropriate) prior to storage.
- Always wash your hands with soap and water before leaving the laboratory even if gloves were worn.
- Shipments of hazardous materials are regulated, and must be processed in accordance with the hazardous materials shipping policy: http://ehs.umass.edu/shipping-hazardous-materials-instructions.
- Hazardous waste is regulated and must be managed in accordance with the hazardous waste policy: http://ehs.umass.edu/hazardous-chemical-waste-hcw-management-guide.

Section 2: General Guidance for Use of Classes of Hazardous Materials

The following provides only the most general of guidance for use of specific classes of hazardous materials. Particular processes should have more specific standard operating procedures in place prior to initiation of work as part of the laboratory specific chemical hygiene plan.

Flammable Liquids

Fire hazards are associated with vapors from a flammable liquid. For a fire to occur, the following conditions must be met:

- Concentration of the vapor must be between the upper and lower explosion limit (UEL, LEL)
- An oxidizing material (e.g., oxygen in the room) must be present
- Source of ignition

Work safely with flammable liquids. Always consider the risk of fire when planning a laboratory experiment with flammable liquids.

- As with all hazardous materials, order only the amounts that are necessary for the work being immediately performed
- Remove all nearby sources of ignition
- Never use an open flame to heat flammable liquids. Preferred heat sources include steam baths, water baths, oil and wax baths, salt and sand baths, heating mantles, hot air or nitrogen baths.
- Wear flame resistant labs coats for use of significant quantities of flammable materials (see the section on lab coats in the PPE chapter of this document).
- When transferring flammable liquids using metal containers, ground and bond both containers to disperse static electricity.
- Store flammable liquids in safety cans, flammable storage cabinets, or flammable storage refrigerators. Ensure that flammable storage cabinets are fully closed when not in use to provide appropriate fire rated protection.
- When possible, use solvent purification systems in lieu of maintaining solvent distillation stills.
- If stills must be used:
    - They must be located in a chemical fume hood with appropriate identifying information including all hazardous materials present and associated hazards, and the name and contact information of a responsible party to contact in case of emergency
    - Do not leave active solvent distillation processes unattended

- When using pyrophoric metals and metal compounds as drying agents or reagents for synthesis, ensure unreacted material is properly quenched and disposed of at the end of the procedure or process and that the material is not allowed to dry. Proper quenching protocols must be in place. See the policy on pyrophoric materials on the EH&S website. Contact EH&S if you need more information.

- Be aware that vapors of flammable liquids are often heavier than air and can travel considerable distance along the floor and benches to potentially meet with sources of ignition.
- Provide as much ventilation as possible to dilute flammable vapors and prevent formation of gaseous explosive mixtures. Use the hood purge button, if present, in the event of a spill to dilute vapor in a chemical hood. Use the red room purge button, if present, to dilute vapor from spills in the room outside of a chemical hood.

Highly Reactive or Explosive Materials

Highly reactive chemicals that are inherently unstable can react in an uncontrolled manner to liberate heat, toxic or flammable gases, or lead to an explosion. They include high energy oxidizers (Appendix F) and shock sensitive materials (Appendix G). Examples of shock sensitive materials may include many acetylides, azides, organic nitrates, nitro compounds, azo compounds, perchlorates, and peroxides (including those formed by peroxide forming materials, See Appendix H). Note that specialized procedures exist and must be followed for work with pyrophoric materials and azides (see section 3 of this chapter).

Before working with these materials, safety information should be reviewed by both the Principal Investigator and lab personnel to evaluate proper storage and handling procedures. The improper handling of these materials may result in a runaway reaction that can become violent. *Careful planning of experiments using reactive or shock sensitive materials are of utmost importance to avoid serious incidents and/or injuries.* As with all experiments, a risk assessment should be conducted and documented. All procedures and experimental apparatus used in the handling of highly reactive or explosive chemicals must be approved by the Department Head/Chair and reviewed and approved by EH&S and the Institutional Chemical Safety Committee prior to commencement of any work. (See the section on risk assessment in this document and section 5 of this chapter for experiments requiring prior approval).

Procedures for working with these materials should include:

- Make sure emergency equipment is at hand, including appropriate fire extinguishers. Class D extinguishers, or other extinguishing media, are necessary for work with materials that pose a risk for a metal fire.
- Secure reaction equipment properly. Set up the apparatus in a way to allow for the immediate removal of any heat source, cooling of the reaction vessel, cessation of reagent addition, and closing of the laboratory chemical hood sash.
- Use impact protection (shields and guards) for high hazard items, in addition to chemical splash protection (eye protection, gloves, lab coats). All eye protection must conform to ANSI standard Z87.1 2010 or 2015. Personal protective equipment (PPE) use is **NOT** a substitute for proper engineering controls (i.e., ventilation or enclosing the process, etc.).
- Handle shock-sensitive chemicals gently to avoid friction, grinding, and impact.
- Handle the smallest amount of reactant when attempting a hazardous reaction.
- Conduct a risk assessment before scaling up any reaction in which an explosive substance is used or could be generated.
- Use a safer material whenever possible.

Peroxide Forming Materials

Under normal storage conditions, peroxides can form and accumulate in some materials (see Appendix H for some common peroxide forming compounds). Peroxides may then explode violently when the materials are subject to thermal or mechanical shock, or may, in some cases, initiate violent polymerization. To prevent incidents, peroxide forming compounds should be identified, dated upon opening, inventoried, and evaluated for safe use every three months (e.g., testing for peroxides). Peroxide forming materials are labeled with the received date and a sticker to indicate testing dates when they are first received on campus and inventoried in the CEMS system (see chapter 8 section 1 for a discussion on CEMS). Test strips are also provided with the materials. Additional test strips can be requested through the CEMS system. General guidelines for peroxide forming material use include:

- Do not store peroxidizable compounds in colorless glass bottles. Formation of peroxides is catalyzed by light. Light can also catalyze the decomposition of peroxides resulting in an explosion.
- NEVER open or move a bottle of a peroxide forming liquid material if a solid precipitate is present in the bottle or along the bottle's cap. This is an emergency situation and requires immediate notification of EH&S.
- It is good practice to check the peroxide levels in peroxide forming solvents with test strips prior to using them in procedures that would involve concentrating the peroxides (i.e., rotovapping, distilling, recrystallizing, etc.).
- Expiration dates should be adhered to, unless a peroxide test demonstrates the material is peroxide free.
- Peroxide forming materials must be tested for peroxides every three months and the results and date of this test noted on the yellow sticker on the bottle. This includes peroxide forming solvents in solvent purification systems.
- Refer any containers of peroxide forming materials that give a positive peroxide test to EH&S immediately for disposal as hazardous waste.

Corrosives

Corrosive chemicals include, but are not limited to, strong acids and bases, dehydrating agents, certain metal chlorides, and halogens. These chemicals are acute health hazards and create risk in handling and storage.

- Strong bases should not be stored in glass bottles, particularly those with ground glass joints. Base reacts with the surface of glass to potentially contaminate the solution and to fuse the glass joints together.
- Liquid concentrated acids and bases should be purchased in coated glass or plastic bottles to contain spills in the event of breakage.
- Corrosives must be stored below eye level.

- Chemical splash googles are recommended for use with corrosive materials. Face shields must also be used for larger quantities of concentrated materials (e.g., base baths, liter scale operations, etc.) or for operations where splashes are likely. Large quantities of liquid corrosives (e.g., base baths) must be stored in secondary containment.
- Thick rubber aprons and thick gloves (in addition to lab coats and appropriate eye/face protection) should be considered for operations likely to generate splashes.
- When preparing solutions, concentrated acids and bases must always be added in small portions with intermittent mixing to water to avoid bumping caused by the potentially highly exothermic mixing process.
- Clothing or lab coats which have had even mild corrosives spilled on them must be removed immediately. Water will evaporate, concentrating the corrosive, which can lead to serious burns on prolonged exposure.
- Use of hydrofluoric acid, hydrogen fluoride or other materials capable of liberating soluble fluoride ion capable of penetrating the skin requires SOPs which have been approved by the Department Head/Chair, EH&S and the Institutional Chemical Safety Committee. All labs which store or use hydrofluoric acid, hydrogen fluoride or other species capable or liberating soluble fluoride ion capable of penetrating the skin are required to maintain a supply of unexpired 2.5% calcium gluconate gel in their First Aid kits. Contact EH&S at (413)-545-2682 if you are in need of calcium gluconate.
- Use of perchloric acid, piranha, and aqua regia are covered by a specific SOPs. See the next section.

Compressed Gases

Compressed gases may present both physical and health hazards. The exact nature of these hazards depends on the type of gas, quantity, and procedure in which it is used. Highly toxic, pyrophoric, and reactive gases require specialized handling and storage procedures, which must be vetted by the Department Head/Chair, EH&S and the Institutional Chemical Safety Committee (see section 5 of this chapter, and Chapter 5 section 1). All use of compressed gases must follow the SOP for compressed gases on the EH&S website. General storage and handling for gas cylinders include:

- Cylinders must be clearly marked with their contents.
- Regulators must be used in accordance with manufacturer's specifications. Never modify a gas regulator or use it for a gas for which it was not designed to be used.
- Cylinders must be secured to a wall or bench, or other immovable object. Approved gas cylinder carts or stands are also acceptable.
- A cylinder cap or regulator must always be attached to the cylinder.
- Cylinders must be transported on an approved cart and the cylinder cap must be firmly in place.
- Full cylinders should be stored away from empty cylinders. Empty cylinders must be returned to gas suppliers on a regular basis.
- Oxidizing gases (e.g., oxygen) must be stored at least 20 feet away from flammable gases (e.g., hydrogen).
- Do not store gas cylinders in cabinets with liquid acids and bases. Corrosion can compromise the integrity of the gas containers and cause valves to seize.
- With the exception of highly toxic, pyrophoric, and reactive gases, the use of lecture bottles is discouraged as these containers cannot be returned to the gas supplier. The

disposal of lecture bottles is extremely costly. See the university's policy on lecture bottles: https://ehs.umass.edu/hazardous-lecture-bottle-purchase-and-use-policy.

Hazardous Materials with Highly Acute and Chronic Toxicity

Certain chemicals have been identified as causing acute health effects or long-term chronic health effects. Substances of high acute toxicity cause *immediate* health effects at very low concentrations. Some examples of chemicals with high acute toxicity are the gases hydrogen cyanide, phosgene, and arsine. The GHS hazard classification system defines acutely toxic substances based on toxicity level and exposure route (see Figure 5). Category 1 items are the most acutely toxic.

Figure 5: GHS Acute Toxicity Hazard Categories Criteria

Exposure Route	Category 1	Category 2	Category 3	Category 4
Oral (mg/kg bodyweight)	≤5	>5 and ≤50	>50 and ≤300	>300 and ≤2000
Dermal (mg/kg bodyweight)	≤50	>50 and ≤200	>200 and ≤1000	>1000 and ≤2000
Inhalation-Gases (ppmV)	≤100	>100 and ≤500	>500 and ≤2500	>2500 and ≤20000
Inhalation-Vapors (mg/L)	≤0.5	>0.5 and ≤2.0	>2 and ≤10	>10 and ≤20
Inhalation-Dusts and Mists (mg/L)	≤0.05	>0.05 and ≤0.5	>0.5 and ≤1.0	>1.0 and ≤5.0

Increasing Toxicity

Substances that have high chronic toxicity cause damage after repeated exposure over a period of time. These may include, but are not limited to, carcinogens, reproductive toxins, mutagens, teratogens, sensitizers and materials with specific target organ toxicity. All laboratory personnel of childbearing age should be notified of any reproductive toxins being used in the laboratory. Any employee who is pregnant or planning to become pregnant should contact their personal physician or the occupational health physician at UHS to assess potential exposures. EH&S can assist in obtaining information for the assessment.

The following guidelines should be used for all work with items of highly acute or chronic toxicity.

- All work with materials classified under GHS as:
  - Acute Toxicity Category 1 through any route of exposure
  - Carcinogenicity Category 1 through any route of exposure

- Germ Cell Mutagenicity Category 1 through any route of exposure
- Toxic To Reproduction Category 1 through any route of exposure
- Specific Target Organ Toxicity Category 1, Single or Prolonged Exposure

must be conducted in a designated area. See Section 5 of this chapter for additional details.

- All work with materials classified under GHS as:

  - Acute Toxicity, category 1-2 inhalation route exposure for any material which is a gas
  - Acute Toxicity, category 1 for any route of exposure

  must receive prior approval by the Institutional Chemical Safety Committee and must be conducted in a designated area. See Section 5 of this chapter for details.
- Designated areas must be clearly defined and marked.
- Notify all employees of the particular hazards associated with this work.
- Minimize contact with these chemicals by any route of exposure (inhalation, skin contact, ingestion, or injection).
- Always wear appropriate personal protective equipment (PPE). Contaminated PPE should be decontaminated prior to leaving the designated area. If decontamination is not possible, consider wearing disposable PPE. Refer these items to EH&S for disposal once the work is complete.
- Designated areas must be decontaminated in so far as possible upon completion of work with hazardous materials. Cleanup can be made easier by use of plastic backed bench paper, Pigmat (chemically absorbent padding), or other types of disposal coverings. Refer these items to EH&S for disposal once the work is complete. Do not conduct normal laboratory work in the designated area until decontaminated.

DHS COIs

Certain chemicals (approximately 300 total) have been identified by the Department of Homeland Security (DHS) as being chemicals of interest (COIs, https://www.dhs.gov/publication/cfats-coi-list) that have a potential to be used for nefarious purposes if not appropriately safeguarded. These items are regulated under the chemical facility anti-terrorism standards (CFATS). CFATS requires each institution that possesses, uses, or ships COIs above certain threshold quantities to report these items to DHS. If identified as a high risk facility by DHS, the institution must develop a specific security plan.

Even for facilities which are not deemed high risk, it is important to ensure security of COIs (and all chemicals), by controlling access to laboratories, and to ensure that all hazardous materials that are brought into labs are accounted for in the CEMS inventory system to maintain compliance with CFATS.

Controlled Substances

Controlled substances are regulated at a federal level by the US Department of Justice Drug Enforcement Administration (DEA), and in the Commonwealth by the Department of Public Health (MADPH). The DEA has created schedules for controlled substances (https://www.deadiversion.usdoj.gov/schedules/) that have varying requirements for each schedule group. Schedule placement is based on the potential for legitimate medical use and also the propensity to be abused. Drugs that are not used therapeutically and that have a high potential for abuse are placed on the lowest number schedules. DEA and MADPH permits are required to purchase, store, and use controlled substances. Each PI is required to obtain their own permit and comply with the specific requirements for storage, inventory, use, and disposal.

Pesticides

Application of pesticides/herbicides/fungicides to crops is beyond the purview of this Chemical Hygiene Plan. All individuals involved with applications of such materials are required to have Worker Protection Standard training. Permits are required for the use of restricted use pesticides in accordance with 333 CMR 10, and for experimental use of pesticides in accordance with 333 CMR 7. Work with small quantities of pesticides in a laboratory setting should be conducted according to standard chemical hygiene practices as described elsewhere in this document.

Section 3: Specific Policies for Particular Hazardous Materials

Environmental Health and Safety, in conjunction with the Institutional Chemical Safety Committee, has prepared a number of Standard Operating Procedures (SOPs) for particular hazardous materials. These are available on the EH&S website and are posted as they are created and adopted.

Section 4: Laboratory Specific Safety Procedures and Chemical Hygiene Plan

Laboratories are also required to develop their own SOPs for operations with hazardous materials and processes that are specific to the lab. These are required components of the laboratory specific chemical hygiene plan that each P.I. must put in place for his or her lab. Components of this plan must include:

- Individual responsibilities for chemical hygiene within the laboratory or department
- Specific hazard communication procedures used in the laboratory, and special hazards present
- Specific policies for the lab
    - Procedures for SOP development and risk assessment, including criteria for what experiments require prior approval of the P.I.
- Specific SOPs for the lab
- Hazardous material storage and segregation procedures
- Location of emergency equipment
- Lab specific emergency procedures, including but not limited to:
    - Equipment shutdown
    - Spill response
    - Exposure response
    - Evacuation route and assembly location
    - Lab member contact information
- Description of, and sign off information for, hands-on training provided in the lab, including but not limited to:
    - Specialized lab techniques (e.g., particular techniques for handling of hazardous materials, use of hazardous equipment, SOPs, etc.)
    - Use of specialized equipment within the lab (e.g., chemical fume hoods, biosafety cabinets, gloveboxes, specialized emergency equipment, etc.)
    - Appropriate specialized emergency response (e.g., spill response or first aid, etc.)
    - Use and care of specialized personal protective equipment

A template that may be used for the creation of a lab specific chemical hygiene plan and SOPs is included as Appendix I in this document. Additional SOPs are available on the Environmental Health and Safety website that may be used for specific processes using particular hazardous materials.

Section 5: Experiments Requiring Prior Approval and Designated Areas

Some experiments present unique hazards and must be conducted in special locations (i.e., designated areas) and, in some cases, require prior approval.

Experiments Requiring a Designated Area

Any substance which is classified under GHS as:

- Acute Toxicity Category 1 through any route of exposure
- Carcinogenicity Category 1 through any route of exposure
- Germ Cell Mutagenicity Category 1 through any route of exposure
- Toxic To Reproduction Category 1 through any route of exposure

- Specific Target Organ Toxicity Category 1, Single or Prolonged Exposure

must be used only in a designated area of the lab that is clearly defined and marked as such. This may be a chemical fume hood, a glove box, or other area of the lab. It is permissible to have more than one designated area in each lab. All personnel working in the lab space should be aware of the area, the potential hazards and any specific emergency procedures. Designated areas must be decontaminated in so far as possible upon completion of work with hazardous materials. Cleanup can be made easier by use of plastic backed bench paper, Pigmat (chemically absorbent padding), or other types of disposal coverings. Refer these items to EH&S for disposal once the work is complete.

Experiments Requiring Prior Approval and a Designated Area

Experiments that can be classified as high risk must receive prior written approval by the P.I., Department Head/Chair, EH&S and the Institutional Chemical Safety Committee (ICSC). These experiments must be conducted in a labeled designated area segregated from the normal operations of the laboratory. The designation of what constitutes a high risk experiment should be determined by a thorough risk assessment. Some experiments may be classified as high risk because they utilize, generate, or have the potential to generate hazardous materials that present exceptional hazards. These materials included anything that can be classified under GHS as a:

- Pyrophoric liquid
- Flammable gas, category 1 with the hazard statement: Ignites spontaneously on contact with air
- Organic Peroxide, Type A-B
- Explosives, Division 1.1-1.3
- Self-Reactive, Type A-B
- Acute Toxicity, category 1-2 inhalation route exposure for any material which is a gas
- Acute Toxicity, category 1 for any route of exposure

There are a few exceptions to the above. Small scale use of sodium azide as a preservative does not require prior approval, however, a designated area should be established for weighing of the bulk material. Other exceptions may be granted through the ICSC.

Additionally, any process which may be classified as high risk through an appropriate risk assessment should receive prior approval. These include, but are not limited to:

- Other chemicals/activities that have a significant probability (based on incident history in the literature) to cause a lethal event (e.g., explosion).
- Any chemical process or procedure which the Department Head/Chair has determined to be particularly hazardous and requires approval.
- Any laboratory procedure or activity that cannot be conducted in accordance with the guidelines established in this Laboratory Health and Safety Plan / Chemical Hygiene Plan and other state and federal regulations and guidelines.
- Any operation using 50% or greater hydrogen peroxide
- Any operation using 85% or greater perchloric acid (or ≤ 85% and heated)

To submit experiments for approval, provide an SOP (you may use the template in Appendix J) for the procedure to the Department Head/Chair, EH&S, and the ICSC.

Chapter 7: Personal Protective Equipment

Personal protective equipment (PPE) is the last line of defense for hazard mitigation, and should only be relied on to mitigate hazards that persist after substitution, engineering controls, and administrative practices have been exhausted. PPE are articles that are worn to provide a barrier to specific areas of the body from hazardous materials or conditions. PPE must be selected such that it is appropriate for a given situation (e.g., not all gloves will protect you from all things in all situations). Training on PPE selection, how to put on (i.e., don) and take off (i.e., doff), clean and care for PPE that is required to be worn by lab personnel is provided by both Environmental Health and Safety and the P.I.

Standard eye protection and lab coats are provided when lab personnel first attend lab safety training with EH&S or during the first class for teaching laboratories. It is the responsibility of the P.I. to provide any additional or alternative PPE that may be necessary for particular work, and to provide appropriate PPE to visitors of laboratories. EH&S is always happy to advise on and help with the selection of appropriate PPE.

Section 1: Eye and Face Protection

Appropriate eye protection must be worn whenever there is a possibility that a hazardous material could enter the eye. Face protection must be worn in addition to eye protection when necessary (e.g., when there is a possibility for a sizable splash to the face), and not as a standalone item. Eye and face protection must be evaluated regularly for damage and deterioration. Items that show significant wear must be discarded and replaced. PPE items that are shared must be appropriately cleaned and disinfected prior to each use.

Eye Protection

All individuals entering or working in a lab with hazardous materials or with processes capable of generating projectiles or splashes are required to wear appropriate eye protection. Ordinary prescription glasses do not provide appropriate eye protection. Minimum eye protection consists of safety glasses that comply with the ANSI 2010 or 2015 Z87.1 standard and have the Z87+ marking. A pair of safety glasses or chemical splash googles are selected by and provided to every new lab member free of charge during the introductory lab safety training. Work with lasers and other types of non-ionizing radiation may require specialized eye protection, the nature of which depends on the wavelength and power of the light source. Chemical splash googles are recommended for procedures that are likely to generate splashes, mists, dusts, etc., particularly for work that uses hazardous materials or generates hazardous materials that are categorized under GHS as:

- Serious Eye Damage Category 1
- Germ Cell Mutagenicity Categories 1A and 1B through a dermal route of exposure
- Carcinogenicity Categories 1A and 1B through a dermal route of exposure
- Toxic to Reproduction Categories 1A and 1B through a dermal route of exposure

- Specific Target Organ Toxicity Category 1, single or prolonged exposure through a dermal route

Chemical splash goggles are meant to protect the eyes from splashes of liquid hazardous materials and from impact. These have a rubber seal that will make contact with your face. Some chemical splash goggles will also protect your eyes from vapors, however, many will not. Most chemical splash goggles have indirect vents that allow for air circulation so that they do not fog up. Only chemical splash goggles that do not have any vents are appropriate for protection from vapors. (Keep in mind that one should use engineering controls first to mitigate hazards, which is easily accomplished by use of a chemical fume hood.) Please note that direct venting goggles (e.g., woodshop goggles) are not appropriate for protection from splashes of hazardous materials. Chemical splash goggles must minimally meet the testing requirements of the ANSI 2010 or 2015 Z87.1 D3 designation for splashes. Check with EH&S if you have questions regarding the suitability of particular products for particular applications.

Safety glasses are not designed to provide protection from liquid splashes. They are only meant to provide protection from impact. As such, they are not an appropriate substitute for chemical splash goggles. Safety glasses are appropriate for work with some tools and machinery, grinding material and other types of activities where solid projectiles are generated.

Face Protection

Face shields are meant to provide secondary protection of the face from impact and splashes. Properly fitting face shields extend from the brow to below the chin. Appropriate eyewear (i.e., chemical splash googles or safety glasses) is always required as primary protection. Therefore, face shields must always be worn in conjunction with appropriate eye protection. Face shields must meet the specifications outlined in the ANSI 2010 or 2015 Z87.1 standard as required for particular applications. Contact EH&S for assistance or questions regarding PPE selection, use, and limitations.

Section 2: Gloves

Appropriate gloves must be worn when handling all hazardous materials. Manipulation of cryogenic materials and items at elevated temperatures requires the use of thermally insulated gloves as appropriate. Cut and puncture resistant gloves may be appropriate for applications where there is high risk of cut or puncture injury occurring. Gloves must be selected such that they provide adequate protection from the material that is being used. The protection afforded by gloves for specific hazardous materials is generally controlled by the type of material from which the glove is made, the thickness of the material, and the length of time in contact with the hazardous material. Not all glove materials are compatible with all hazardous materials. For example, acetone can readily penetrate exam grade nitrile gloves, but 14 mil (0.35 mm) thick butyl rubber can provide an effective barrier. The thickness of the glove also is important. The thicker the glove, the longer it will take a hazardous material to break through (i.e., penetrate) the barrier. The length of time the hazardous material is in contact with the glove is also of critical importance. For this reason, contaminated gloves must be removed immediately to prevent breakthrough. Contact time is generally controlled by the application, or the process, in which the glove is being used. For incidental contact with hazardous materials, it is usually acceptable to wear exam grade (e.g., 4 mil thick) gloves made of an appropriate material. For prolonged and/or greater than incidental contact, thicker gloves may be necessary. Double-gloving may also be used to provide greater protection. SilverShield gloves are also a good choice for high hazard items or prolonged contact. Recommendations for appropriate choice of gloves are frequently listed in SDSs for given hazardous materials. Glove manufacturers also generally provide data from breakthrough tests with particular hazardous materials on their websites or by request. Note: Latex gloves should not be used due to the high proportion of individuals that acquire latex sensitivities. Consultation with EH&S can be helpful in selecting appropriate gloves for given applications.

Gloves should ideally be worn whenever any hazardous materials are manipulated by hand. They must be worn whenever there is the possibility of hand contact with any materials that are classified under the GHS system as:

- Acute toxicity-Dermal Categories 1, 2 or 3
- Skin Corrosion Categories 1A, 1B or 1C
- Sensitization-Skin Categories 1A or 1B
- Germ Cell Mutagenicity Categories 1A or 1B through a dermal route of exposure
- Carcinogenicity Categories 1A or 1B through a dermal route of exposure
- Toxic to Reproduction Categories 1A or 1B through a dermal route of exposure
- Specific Target Organ Toxicity Category 1, single or prolonged exposure through a dermal route of exposure

As gloves are worn to protect the wearer from contact with hazardous materials, it is important not to contaminate common spaces and clean areas by touching surfaces with gloved hands. Similarly, handling personal items such as cell phones and laptops with gloved hands can contaminate those items. Gloves must be removed promptly after the completion of work, and must be changed frequently to prevent breakthrough and contamination of clean areas. Hands should be thoroughly washed after wearing gloves and before exiting the laboratory.

As gloves worn in the laboratory are contaminated, gloves must not be worn outside of the laboratory. If there is a need to transport a hazardous material from the lab, use appropriate secondary containment such that the use of gloves is not necessary.

Section 3: Lab Coats and Other Protective Apparel

Appropriate lab apparel begins with proper selection of clothing that adequately covers the body. Lab attire should be selected such that:

- As much skin as possible is covered on the body. Shorts and open toed shoes are not permitted in labs where hazardous materials are in use. Shoes with narrow heels are not appropriate for lab work as the heels can be caught in floor drains and create a tripping hazard.

- It is not loose fitting such that it creates a safety hazard by, for example, potentially causing spills or getting caught in equipment.
- It is not overly form fitting such that it would trap chemicals spilled on it next to your skin.
- It should be compatible with the chemicals used such that the integrity of the fabric is not compromised, or that it would otherwise create an additional hazard by adversely reacting with the chemical materials in use. Natural fabrics, such as cotton, are generally the best choice.
- Flame resistant fabric is the best choice for work with open flames.

Lab Coats

In addition to wearing appropriate lab attire, all laboratory personnel are required to wear a lab coat while working with hazardous materials. Lab coats are available to research laboratory personnel through the lab coat management program administered by EH&S. Three types of coats are available for different applications:

- White, poly-cotton blend appropriate for general laboratory work
- Light Blue, flame resistant, 100% cotton appropriate for work with flammable and pyrophoric materials
- Royal Blue, flame resistant Nomex material treated to resist certain chemicals (by request only)

Lab coat selection and sizing is conducted through the EH&S website: https://ehs.umass.edu/lab-coat-management-program. Laundering is available through the program for soiled coats. Courtesy coats are available for use while coats are being laundered.

Aprons and Disposable Garments

For manipulation of highly corrosive or larger quantities of materials, it may be appropriate to wear additional or alternative protective apparel. Butyl rubber aprons are appropriate for work with strong acids or other highly corrosive materials, though they do not cover the arms. Lab coats and aprons that are disposable are generally made from spun polypropylene and other proprietary blends of polymeric fabrics (e.g., Tyvek, Tychem). These must be chosen carefully to ensure they provide appropriate resistance to the hazardous materials with which they are used. Disposable lab apparel is typically appropriate for protection from biological materials, and therefore may not provide adequate protection from non-aqueous liquids or highly corrosive materials. Consultation with EH&S is recommended to discuss what types of and under what conditions additional lab apparel is appropriate and prior to selection of specific items.

Section 4: Respiratory Protection

Respiratory protection from hazardous materials in a lab is generally achieved by means of engineering controls (e.g., chemical fume hoods). The use of respirators, including filtering face pieces, is discouraged because they protect only the wearer and require annual medical monitoring, specific training, and fit testing to be sure they can be worn effectively. However, in certain situations, it may be necessary to rely on PPE such as negative pressure air purifying respirators or particle filtering face pieces to achieve exposure limits that are below regulatory thresholds. If there is reason to suspect that use of engineering controls is not sufficient to provide exposure levels below regulatory limits, exposure monitoring will be performed by EH&S. If exposure levels are found to exceed the regulatory limits, the affected individuals will be medically evaluated, fit tested, trained and supplied with an appropriate respirator in accordance with the Respirator Protection Program (https://ehs.umass.edu/respiratory-protection-program). In situations where respirator use is not required, but lab personnel voluntary choose to wear respiratory protection, consultation with the EH&S administrator of the Respiratory Protection Program is encouraged to determine if medical evaluation and fit testing are necessary.

Please note that surgical masks are not the same as filtering face piece respirators. Surgical masks afford no protection to the wearer from hazardous materials or dusts, but are rather worn to prevent contamination caused by the wearer to experiments or patients.

Chapter 8: Chemical Procurement, Storage, Security

Government regulations, such as those from the Department of Homeland Security and the Environmental Protection Agency, require that the University maintain an accurate chemical inventory of hazardous materials and quantities. UMass Amherst uses the University of New Hampshire's Chemical Environmental Management System (CEMS) as an inventory database, a system for requesting disposal of hazardous waste and laboratory supplies, and as a repository of chemical safety information (SDSs).

Section 1 – Procurement, Distribution and Maintenance in CEMS

To maintain a chemical inventory for the campus, and for each individual laboratory, all chemical acquisitions must be logged. This is achieved by having all chemicals that are acquired sent through a central location on campus where they can be bar-coded and entered into the CEMS system before distribution to the laboratory. Instructions for acquisition of materials are available on the EH&S website at: http://ehs.umass.edu/cems-hazardous-material-inventory-management.

Inventory

- When ordering a hazardous material make sure the ship to address is 710 North Pleasant St, LGRT 179 and under the Attention line have the professor's name and lab room number where the material will be stored at.
- To maintain an up to date inventory EH&S CEMS Dept. will periodically re-inventory the chemicals in the laboratories. You may also choose to have your lab re-inventoried if needed by contacting EH&S CEMS Dept. (413) 577-3633

Empty containers

- Once a chemical has been used and the container is empty, remove the barcode and attach the bar code to the Inventory Disposal Log Form
- The bar code to the Inventory Disposal Log Form can be found here: http://www.ehs.umass.edu/chemical-inventory-disposal-log-form. Staff from EH&S will drop by periodically to pick up your sheet and update your inventory.

Transfer of containers

- To transfer chemicals to a different lab location under the same PI, go into CEMS; Go to Quick Links-Contact EH&S-and fill in the blanks.
- When the transfer is a result of a lab move or change in responsible owner, please notify EH&S CEMS at (413) 577-3633. Do not remove barcodes.

Disposal of chemicals as Hazardous Waste

- When requesting a regular hazardous waste pick up, be sure the barcodes are removed and placed on the Inventory Disposal Form

- When performing a larger lab cleanout (more than 10 bottles/boxes), call EH&S CEMS staff at (413) 577-3633 to have the chemicals scanned prior to pick-up.

Section 2-Chemical Storage

Appropriate storage of hazardous materials in laboratories and stockrooms is of primary importance for both safety and regulatory compliance. Many chemicals are incompatible with one another and therefore must not be stored together. Other items, like flammable or combustible materials, present fire and health risks if not stored appropriately. Chemical segregation can be a complicated process if laboratories have a large quantity of chemicals and limited space. The following are some general guidelines for storage. Please consult EH&S for specific questions. An example of a simple storage scheme for common laboratory chemicals can be found in Appendix K of this document.

- Maintain the smallest stocks of chemicals in the lab that is practical. Unnecessary chemical storage takes up valuable space, can lead to regulatory issues of non-compliance for "waste-like" chemicals, increases the risk of an incident, and is expensive from both a purchasing and disposal standpoint. It is often possible to "borrow" small quantities of material from other labs when necessary.
- Minimize the storage of materials on the floor, benches, and in fume hoods**.** Storage of items in the fume hood can negatively affect the airflow.
- All materials should be stored with labels facing forward such that the label of the container can be read without moving the container. Minimize crowding.
- Flammable materials not in use must be stored in an approved flammable materials cabinet, safety cans, a refrigerator or freezer rated for storage of flammable materials, or a room with appropriate ventilation and fire suppression systems in place. Cabinets housing flammable materials must remain fully closed when not in use to provide rated storage. Refrigerators and freezers that are used for flammable material storage must be compliant with the requirements of NFPA 45 and 70. Note that cold rooms and household type refrigerators generally do not meet these requirements, and therefore must not be used for the storage of flammable materials to prevent risk of explosion. Food and drink must never be stored in a laboratory refrigerator or freezer.
- Acids and bases must be separated.
- Oxidizers must be stored separately from organic materials and all materials that are flammable or combustible.
- Corrosive and toxic materials may not be stored above the benchtop level. Generally, no hazardous material should be stored above "eye-level" to minimize accidents while reaching overhead. Large containers should be stored on lower shelving.
- Liquid materials should have secondary containment (e.g., a lipped shelf or bin) and only compatible materials may be stored in the same secondary container.
- Water reactive materials must be supplied in packaging that adequately protects the materials from moisture, or should be stored in desiccators, an inert atmosphere (e.g., glove box), or be otherwise protected from moisture (*e.g.*, sodium in mineral oil). Pyrophoric materials must be similarly supplied in appropriate packaging and protected from air.
- Peroxide forming materials (e.g., ethers, compounds with tertiary, allylic and benzylic hydrogen, and any other compounds that can easily form free radicals) must be labeled as such, and must be tested for peroxides regularly if opened, and at least every three

months. See the section on peroxide forming materials in Chapter 6 section 2 of this document. See Appendix H of this document for a list of common peroxide forming materials.

- Volatile and toxic materials must be stored in well-ventilated areas. Note that cold rooms have recirculated air, and as such, are not appropriate for toxic materials or gases that can accumulate or displace oxygen.
- Do not store gas cylinders in confined spaces (e.g., cabinets) with liquid corrosives. Corrosive vapors will deteriorate the metal cylinders and potentially seize the cylinder valve. Metal items and containers must not be stored with liquid corrosive materials.

Please note that these guidelines are for general storage. The extent to which the chemicals in your laboratory need to be segregated depends on the quantity and type of materials in your laboratory. In general, if two chemicals react with each other, then they should not be stored together. Please contact EH&S if you have specific questions about hazardous material storage.

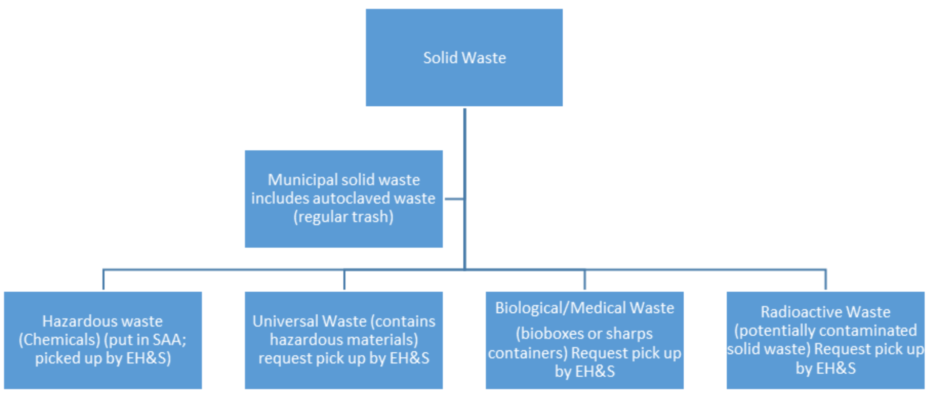
Section 3-Security

Chemical security is an issue that is becoming increasingly important for laboratories and associated areas. The following are guidelines that must be employed in all laboratory and storage spaces. Additional requirements may be necessary for specific areas with specific items.

- Keep all laboratories locked when unoccupied.
- Keep an accurate record of chemicals, stocks, cultures, project materials, growth media, and those items that support project activities.
- Notify UMass police if materials are damaged or missing from laboratories.
- Inspect all packages arriving into the laboratory before opening them. Even if delivered, do not open packages not addressed to you. Seek assistance before opening damaged packages containing hazardous materials.
- Ask strangers (i.e., someone you do not recognize as a co-worker or support staff person) to exit the room if they are not authorized to be there.
- When research is completed for the day, ensure that all hazardous materials have been stored properly and securely.
- Special attention should be given to highly toxic and reactive compounds, controlled substances as listed in 21 CFR 1308, and anything identified by the Department of Homeland Security as a Chemical of Interest as listed in 6 CFR 27 Appendix A. These compounds may need to be stored separately from other items and locked up.
- Discuss other security-specific requirements with your supervisor and colleagues.

Chapter 9: Waste Disposal

Laboratories generate a variety of wastes, all of which must be handled appropriately. Most waste can be defined as a solid waste, which includes common household waste, most recyclable refuse, hazardous chemical waste, and other discarded items. Municipal solid waste is solid waste which is not regulated for disposal and which is not recyclable. Examples from a laboratory would include paper towels, gloves that are not grossly contaminated, used (and empty) plastic pipets and cuvettes. These items can all be placed in the normal trash receptacles. Broken glassware and used Pasteur pipets not contaminated with biological materials or hazardous waste are also municipal solid waste, and these items must be placed in the glass waste boxes available in the laboratories to protect the custodians who remove the trash from the physical hazard. Apart from municipal solid waste, all other laboratory waste is regulated for disposal as it is considered either regulated solid waste, biological/medical waste, or radiological waste. The following details how this waste must be handled. Questions about classifications of specific waste items should be directed to EH&S.



Section 1: Regulated Solid Waste

Most of the laboratories on campus generate chemical waste, either directly through chemical use, or through the use of products and devices that contain chemicals. It is crucial for the health and safety of the campus community and the protection of the environment that such waste is managed appropriately. The federal and state governments—through the Environmental Protection Agency (EPA) and Department of Environmental Protection (DEP), respectively—have also mandated by law that this waste is handled, stored, and disposed of in a specific manner. Very large fines have been imposed on organizations (including colleges and universities) which have failed to meet the requirements of these laws. At a federal level, these laws fall under the Resource Conservation and Recovery Act (RCRA). Under RCRA each state (through a DEP) is charged with enforcement of the specific federal requirements and can enact more stringent regulations as the legislature deems necessary, as is the case in Massachusetts. The following details the major parts of RCRA (40 CFR 239-273) and the DEP regulations (310 CMR 30) that pertain to our laboratories, as generators of regulated solid waste (which includes universal waste and hazardous waste).

Universal Waste and Equipment Disposal

Universal waste consists of specific products and devices of no further use which have hazardous and recyclable constituents. Universal waste items must be handled, labeled and packaged in accordance with federal and state regulations, and cannot simply be tossed in a dumpster or garbage can. Universal waste includes, but is not limited to: certain types of batteries, pesticides, mercury containing equipment, fluorescent lights, computer monitors and television tubes. EH&S works in conjunction with the Office of Waste Management (or the Waste Recovery and Transfer Facility, WRTF) to ensure appropriate recycling and disposal of such items and all equipment from laboratories. If you have equipment that you would like to remove from your laboratory, please submit an SED (Surplus Equipment Disposal) Form through WRTF: https://www.umass.edu/wastemanagement/surplus-property-disposal. The equipment should be decontaminated prior to disposal. Please contact EH&S for consultation on appropriate decontamination procedures when in doubt. EH&S conducts an all hazards review on equipment designated for disposal to ensure that all hazardous constituents have been identified and are appropriately addressed.

Items such as batteries, pesticides, mercury thermometers and manometers should be referred for hazardous waste disposal through CEMS. Please contact EH&S if you have questions about disposal of particular items.

Hazardous Waste

All chemical substances originating from laboratories are treated as "hazardous waste" at UMass. Hazardous waste must be disposed of in accordance with appropriate state and federal regulations and UMass policies and procedures. Please contact EH&S for any questions about specific waste streams. Each area that generates hazardous waste must have a Satellite Accumulation Area (SAA) for that waste. Every member of a laboratory that generates hazardous waste will receive training that covers identifying, labeling, handling and storing hazardous waste on a laboratory scale. This training is required at least annually. Laboratory generators of hazardous waste must follow the requirements below.

- All hazardous waste must be labeled, handled, and stored appropriately in an SAA that is at the point of generation.
- All containers of hazardous waste must be appropriately labeled. Premade labels for containers are available through CEMS by request. Do not use other labels. Provided labels should be filled out to contain the following information:
    - The contents, fully spelled out without abbreviations or molecular formula, and relative quantities of each constituent in the container
    - Applicable hazards (i.e., ignitable, corrosive, reactive, toxic, or other)
    - Name of the generator (typically the faculty member or laboratory director)
    - Phone number of the generator
    - Building and room number of where waste is located

- Containers of hazardous waste in an SAA must be in appropriate secondary containment that is labeled with the orange "hazardous waste" label and is capable of containing the release of 110% the volume of the largest container. Secondary containment bins are available on request through CEMS. No other non-hazardous items should be stored in these secondary containers (e.g., squirt bottles, dirty glassware, sharps containers, etc.) Containers of hazardous waste may be removed temporarily from secondary containment to add additional waste to the container.
- Containers must be selected such that they are compatible with their contents. Containers holding incompatible wastes must be stored in separate secondary containers. Incompatible waste must not be added to the same container.
- Containers must be kept closed unless contents are being added. For contents that might build pressure or evolve a gas on storage, special pressure venting caps are available on request through CEMS. These containers must be kept in an SAA that is within a fume hood or other appropriate ventilated enclosure. Waste that is not likely to generate gas can be kept in an SAA that is not in a fume hood or ventilated enclosure.
- Full containers must be requested for removal through CEMS as soon as they are full and will be removed from the SAA within three days of the request date. Do not date the container.
- Containers and storage areas must be inspected on a weekly basis. Dry erase inspection sheets are available on request through CEMS.

Additional information on hazardous waste is available from the EH&S website. Please contact EH&S with any questions.

Section 2: Regulated Medical/Biological Waste

Medical/Biological waste is regulated in Massachusetts by the Department of Public Health under the State Sanitary Code (105 CMR 480). It includes sharps, waste viable microorganisms, pathological waste, and other items. Disposal of all such waste must be in accordance with the UMass Biological Materials and Biohazardous/Medical Waste Disposal Program: https://ehs.umass.edu/sites/default/files/25%20Biological%20Waste%20Program_0.pdf. Pickup of full bioboxes and sharps containers can be requested through CEMS. Replacement collection containers are also available by request through CEMS.

Section 3: Radioactive Waste

All radioactive waste must be disposed of according to the UMass Radioactive waste collection and disposal program: https://ehs.umass.edu/collecting-and-disposing-radioactive-waste.

Chapter 10: Emergency Equipment and Procedures

In the event of a spill, fire, exposure or other type of likely emergency, procedures and equipment must be in place in the laboratory for response. The nature of likely emergencies will be different for different laboratories, depending on the exact hazards present and the type of procedures employed. The following details equipment and emergency procedures that are likely to be used in a majority of laboratories. All individuals working in a laboratory should be trained on the location and use of emergency equipment that they will be expected to use in an emergency situation. Specialized equipment and procedures should be in place for atypical hazards. Consultation with the EH&S is recommended for these situations.

Section 1: Spill Containment

Spill containment items should be available in all areas where a spill of a hazardous material is likely. The exact nature and number of items necessary for a particular lab depend on the type and quantity of hazardous materials used in the lab. Not all spills can be adequately dealt with by laboratory personnel. Only incidental spills (i.e., spill that can be addressed safely within the lab) should be cleaned up by laboratory personnel, and only if it is safe to do so. Larger spills, highly hazardous spills, or spills which laboratory personnel are not comfortable cleaning up should be referred to EH&S. All spills of hazardous materials to drains must be reported to EH&S.

Absorbent padding, including paper towels, PIG absorbent mat and spill pillows, are generally appropriate for most liquid spills. Spills of elemental mercury require the use of a specialized containment kit, and labs that use elemental mercury, including mercury thermometers, should have such a kit on hand. Laboratories that use hydrofluoric acid, or other concentrated liquid sources of fluoride ion, should also have a specialized spill containment kit on hand. Extremely concentrated acids and bases may require a specialized type of PIG absorbent mat if the quantity of the spill is sufficient, or they can be neutralized prior to absorbing. Appropriate containment strategies and materials can be recommended by EH&S for specialized situations.

All materials from a spill cleanup must be disposed of properly. Generally, these items should be placed in a waste container in the laboratories SAA, however, it is best to consult with EH&S on proper disposal.

Incidental/Small Spill Clean-Up

Only small spills which do not present a high degree of hazard may be cleaned up by lab personnel, and then should only be done if the personnel are comfortable doing so and have the appropriate equipment. All other spills should be referred to EH&S (413-545-2682) for clean-up (see procedure for large spill below).

For small liquid spills:

- Use PIG absorbent mat, spill pillows, other absorbent materials (including paper towels for very small spills) as appropriate to contain and absorb the spill.
- Most materials do not need to be neutralized, but if you have spilled a concentrated and oxidizing acid, use sodium bicarbonate, or other appropriate neutralizing agent, prior to absorbent material. You may also use absorbent material that is specifically designed for strong acids and bases in lieu of neutralizing.
- Dispose of absorbent material in a container for solid hazardous waste in the SAA.
- For spills which could leave a residue, wipe up the area with wet paper towels (or other absorbent material, as appropriate) to remove the residue. Discard this cleanup material to the solid hazardous waste container or plastic bag in the SAA. It is generally a good idea to consult with EH&S for these types of materials to ensure clean-up was thorough and adequate.

For small spills of solid materials:

- If the material is not water reactive, wet it to minimize airborne dust exposure if it is not confined to a fume hood or other ventilated enclosure. If the material is water reactive, contact EH&S.
- Scoop up the material with a paper towel, PIG absorbent mat, piece of cardboard, weigh boat, etc. and dispose of the material in a solid waste container.
- Wipe the area clean with wet paper towels and dispose of these in the solid waste container as well. It is generally a good idea to consult with EH&S for these types of materials to ensure clean-up was thorough and adequate.

Large Spill Response

For large spills, spills of highly hazardous materials, spills for which spill clean-up supplies are inadequate, or spills which lab personnel are not comfortable cleaning up:

- Evacuate the immediate area of the spill, or the room if necessary.
- Call EH&S (413-545-2682).
- Report the identity and quantity of the material that was spilled and obtain the SDS if possible.

Section 2: Chemical Exposures

In the event of exposure to a hazardous material, the affected area must be flushed with water for 15 minutes. Drench showers and eye washes are connected to potable water whereas laboratory sinks are considered non-potable water (except for hand washing sinks). Therefore, it is advisable to flush with drench showers or eye washes rather than sinks.

All exposures, even minor, should be referred to University Health Services (UHS) for evaluation as soon as practical after the exposure.

All lab incidents, including but not limited to injuries and chemical exposures, must be reported to EH&S within 48 hours of the incident by filling out the incident report form on the department's website: https://ehs.umass.edu/lab-incidents-and-lab-incident-report-form (and also as Appendix L of this document). Injuries to UMass employees should also be reported to HR at 413-545-6114.

Eye washes are used to irrigate the eyes in the event of a hazardous material exposure. These are generally activated by depressing a lever, squeezing a handle, or lower a unit attached to a sink. Safety showers are used to irrigate the body in the event of a hazardous material exposure. These are generally activated by pulling on a handle. Individuals should be familiar with and trained on the location and use of the eye wash station and safety shower in their work areas. Affected areas should be flushed for a minimum of 15 minutes as specified in the emergency response procedures that follow.

Eye washes should be flushed weekly for three minutes to prevent the buildup of sediment which could obstruct flow or cause damage to the eyes when the unit is used. It is each PI's responsibility to ensure that individual eyewashes are flushed weekly and that this is documented. Sheets used to document weekly flushing are available on the EH&S website:https://ehs.umass.edu/emergency-eyewash-and-drench-shower-program. Safety showers and eyewashes are flushed and tested twice annually by EH&S. If the tag on a shower indicates that it has not been tested within the last six months, contact EH&S (413-545-2682). Water in eyewashes and safety showers should be at a temperature between 60-90°F as required by the Massachusetts plumbing code, 258 CMR 10. If the water appears to be too hot or cold, or if the flow rate appears to be too high or low (eyewashes should be 0.4 gallons per minute, showers should be at least 20 gallons per minute), contact EH&S for evaluation.

Exposure to the Eyes

In the event that a hazardous material enters the eye, the procedure below should be followed.

- Have someone call 911 (report the building name, room number, and street address) or 413-545-3111 (or simply 5-3111 from a campus line) to report the incident and request medical help. Have someone obtain the SDS for the material and provide it to the first responders when they arrive, if possible.
- Help the affected individual to position their head over the eyewash and activate it
    - Always ensure your own safety before helping others. Only help if it is safe for you to do so.
    - Wear gloves, safety glasses, and a lab coat.
- Instruct the affected individual to open their eyes and roll them around while the water is flowing. Help them to hold their eyes open if necessary and safe to do so.
- Flush the eyes for 15 minutes with water.

Exposure to the Body

In the event that a hazardous material is spilled on the body, the procedure below should be followed.

- Have someone call 911 (report the building name, room number, and street address) or 413-545-3111 (or simply 5-3111 from a campus line) to report the incident and request medical help. Have someone obtain the SDS for the material and provide it to the first responders when they arrive, if possible.
- Help the affected individual to the drench shower.
  - Always ensure your own safety before helping others. Only help if it is safe for you to do so.
  - Wear gloves, safety glasses, and a lab coat.
- Pull the handle to activate the shower.
- Remove all clothing from the affected area while under the water.
- Irrigate the affected area for at least 15 minutes.
- For exposures to special hazard materials (e.g., HF), follow specialized emergency procedures.

Minor Exposures

For exposures which:

- Do not involve acutely toxic materials
- Involve a readily accessible portion of the body (i.e., hand, forearm, etc.) such that the use of an eye wash or safety shower is not necessary
- Are relatively minor in nature (i.e., exposure is minimal and is immediately addressed, etc.)

Follow the procedure below.

- Flush the affected area in a potable water sink for at least 15 minutes.
- Go to University Health Services (UHS) for medical evaluation, and tell them you have had a lab exposure.
- Provide the SDS for the material if possible.
- Notify EH&S (413-545-2682) as soon as possible and complete the lab incident form (https://ehs.umass.edu/lab-incidents-and-lab-incident-report-form and also as Appendix L of this document).

Section 3: Fires

Each lab's chemical hygiene plan should contain procedures for emergency response to fires. A general procedure is included in the template for lab specific chemical hygiene plans

(Appendix I of this document) to which the specific evacuation route, assembly area, and locations of pull stations and fire extinguishers must be added.

If a person is on fire:

- Immediately Stop, Drop, and Roll until the flames are extinguished
- Drench showers may be used if they are immediately available. Do not go in search of a drench shower.
- Fire blankets, and other articles, must never be wrapped around standing individuals. Doing so can create a chimney effect, causing flames to move up the body, and this can produce worse burns than if nothing had been done at all.
  - Fire blankets are only appropriate for smothering a person who is already on the ground.
- If the fire spreads to any items in the building, follow fire procedures for evacuation, including activation of the fire alarm.
- Call 911 (report the building name, room number, and street address) or 413-545-3111 (or simply 5-3111 from a campus line) to report the incident and request medical help.

Section 4: Other Incidents

For other incidents not specifically covered above, follow the laboratory emergency action plan items detailed below.

Injuries

Seek medical treatment. The most important thing to do if you have a work-related injury or illness is to seek appropriate medical treatment. If you receive an injury that needs immediate advanced care, call 911 to summon an ambulance and emergency response personnel for care and transportation to the Cooley Dickinson Hospital's Emergency Department.

If your injury is less than an emergency but still in need of timely medical treatment, you may seek medical attention at the Walk-in Clinic at University Health Services. (Ambulance services cannot transport people to the Health Center).

If a **Major Injury CALL 911**

- Notify occupants in the immediate area
- **If necessary**, evacuate the area, otherwise do not move the injured party.
- Stay with the affected individual until help arrives

If a Minor Injury (but requiring more than a Band-aid)

- Go to University Health Services **413-577-5000** and/or other health care provider

- Report incident to Environmental Health and Safety at **413-545-2682.**
- Incident reports (https://ehs.umass.edu/lab-incidents-and-lab-incident-report-form and also as Appendix L of this document) and Notice of Injury reports should be filed in accordance with University Policy (contact HR at 413-545-6114 for injuries to UMass employees).

Odors, Leaks, Smoke or Other Hazardous Conditions

Call EH&S at 413-545-2682. After 5PM, call UMass PD at 413-545-2121.

Chapter 11: Training and Inspections

Section 1: General Training

Training is required on an annual basis, or whenever conditions change such that refresher or updated training is necessary, for all laboratory personnel (including the responsible individual for the lab). Faculty members are responsible for ensuring that employees and students in their research laboratories receive proper training. EH&S provides basic laboratory and fire safety training. Basic lab and fire safety training provided by EH&S consists of:

- The contents of the Laboratory Standard (29 CFR 1910.1450)
- Institutional policies and procedures applicable to the use of hazardous materials in laboratories, including elements of this chemical hygiene plan and how to access it
- Description of activities requiring institutional approval
- The Massachusetts Right to Know Law and hazard communication including, but not limited to,
    - GHS and NFPA labeling
    - Labeling of items in laboratories
    - How to read a SDS
    - Where to obtain SDSs
- The chemical inventory system (CEMS)
- Chemical storage and handling
- Hazard mitigation techniques, including but not limited to,
    - Engineering Controls, including proper use of chemical fume hoods
    - PPE selection, use, and limitations
- Use of emergency equipment and emergency procedures, including but not limited to,
    - Fire
    - Spill
    - Exposure
- Hazardous waste identification, handling, storage, and disposal
- Sharps

In lieu of basic lab safety training, individuals working in art studios are permitted to take art and fire safety training, and those working in machine shops are permitted to take mechanical and electrical research safety and fire safety training. These courses consist of essentially the same topics outlined above, but with a focus more specific to the processes occurring in the arts and in machine shops. These courses are also required annually

Additional basic training is provided by EH&S for work with biological and radioactive materials and the use of high powered lasers.

Section 2: Lab Specific Training

In addition to the basic training required above, all lab personnel are required to have hands-on, lab specific training provided by the PI or their designee. This training should consist of:

- Relevant elements of the lab specific chemical hygiene plan including, but not limited to,
  - special emergency procedures, including location of emergency equipment
  - specific SOPs
  - specific lab policies
  - unique hazards and hazard communication
- Signs and symptoms of exposure for hazardous materials used in the laboratory including exposure limits
- Special techniques for preventing exposure and release of hazardous materials used in the laboratory
- Ways of detecting the release or presence of specific hazardous materials used in the laboratory

Lab specific training is required at the time of initial appointment and whenever processes or procedures change within the lab, or when an individual's responsibilities change, such that new hazard training is necessary to provide adequate protection. It is recommended that PIs document this training. EH&S is available for consultation in determining what type of training and frequency is necessary along with methods of documentation.

Section 3: Lab Inspection and Assessment Program

EH&S conducts formal lab assessments on at least an annual basis. Reports of deficiencies found during assessments are sent to PIs. PIs are asked to respond in writing within two weeks detailing the corrections made. If a response is not received within the two week timeframe, a reminder is issued and a response must be issued within a week of the reminder. If a response is not issued within a week of the reminder, escalation procedures will begin, including, but not limited to: (1) notifying EH&S leadership and the department chair, (2) notifying the dean of the college, (3) notifying the provost.

If a PI disagrees with deficiencies noted by EH&S on an assessment, they are welcome to raise the issue with EH&S for review and discussion. If no resolution can be reached by consultation with EH&S, appropriate expert parties not affiliated with the University will be consulted to reach a resolution.

PIs are also expected to conduct periodic self-assessments. A checklist that may be used for doing so is located in Appendix E.

Chapter 12: Exposure Monitoring and Medical Treatment

Monitoring of airborne concentrations of hazardous materials is generally not necessary in a laboratory, particularly if control measures, such as proper use of chemical fume hoods, have been employed. If there is reason to believe that exposure levels routinely exceed action levels, or other exposure limits (i.e., PEL, TLV) in the absence of action levels, for hazardous materials specifically regulated by an OSHA standard, then initial employee exposure monitoring will be conducted. If initial employee exposure monitoring reveals that exposure above the action limit (or exposure limit in the absence of an action limit) is occurring, monitoring in compliance with the relevant OSHA standard will be conducted. Results of monitoring will be provided in writing to affected employees within 15 days of receipt. Monitoring will be terminated in accordance with the relevant OSHA standard.

Medical evaluation, including any follow up visits the physician deems to be necessary, will be provided free of charge to employees who work with hazardous materials under the following circumstances:

- Whenever an employee develops signs or symptoms of exposure to a hazardous material to which they may have been exposed.
- Whenever exposure monitoring reveals exposures that routinely exceed the action level, or other exposure limits in the absence of an action limit, for hazardous materials for which exposure monitoring and medical surveillance is required by a particular OSHA standard
- Whenever an there is an incident (e.g., leak, spill, explosion, etc.) where exposure is probable

Medical evaluations will be provided by or under the direct supervision of a licensed physician and will be provided at a reasonable time and place. Employees will not incur a loss of pay for such evaluation. The following information must be provided to the physician by the University:

- The identity of the hazardous material(s) to which the employee may have been exposed.
- A description of the conditions under which the exposure occurred, including quantitative exposure data, if available.
- A description of the signs and symptoms of exposure that the employee is experiencing, if any.

The physician must issue a written opinion to the University that must include the following information:

- Any recommendations for further follow up
- The results of the medical examination and any associated tests
- Any medical conditions identified during the course of the evaluation that may place the employee at increased risk as a result of exposure to hazardous materials

- A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition which may require further examination or treatment.

The written opinion must not contain information pertaining to medical conditions unrelated to hazardous materials exposure.

The University will maintain for each employee an accurate record of any measurements taken to monitor employee exposure and any medical consultation and examinations including tests and written opinions. The University will assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.1020.

Appendix A: General Definitions and Abbreviations

CEMS: See Chemical Environmental Management System

Chemical Environmental Management System: The chemical inventory database used by the University and the area of Environmental Health and Safety that manages the database and centralized receiving and delivery of hazardous materials for the campus.

Chemical Hygiene Officer: An employee designated by the University who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan.

Chemical Hygiene Plan: This document and the procedures and programs described therein.

CHO: See Chemical Hygiene Officer

CHP: See Chemical Hygiene Plan

Designated Area: An area of a laboratory, or in some cases, an entire laboratory, where work with particular hazardous materials or processes occurs.

EH&S: Environmental Health and Safety

Engineering Controls: Equipment or modifications to equipment that are used to lower exposure to hazardous materials or situations

Faculty: For purposes stated in this document, a faculty member**,** who may or may not be the primary person responsible for the administration of a research grant, and is responsible for ensuring that university health and safety policies are adhered to in their laboratory.

GHS: See Globally Harmonized System

Globally Harmonized System: A means of hazard communication developed by the United Nations and employed in full or in part in many nations as the standard mechanism for communicating hazards of hazardous materials. This is the currently federal hazard communication standard codified by 29 CFR 1910.1200 and associated appendices.

Hazard Communication Standard: The regulation detailed in 29 CFR 1910.1200 and associated appendices, which requires manufacturers of hazardous materials to communicate the hazards of those materials by means of container labels and safety data sheets.

Hazardous Material: Any material which may be classified, or for which there is evidence or knowledge to suggest that it could be classified, as a hazardous chemical under the Hazard Communication Standard (29 CFR 1910.1200).

IACUC: See Institutional Animal Care and Use Committee

IBC: See Institutional Biosafety Committee

ICSC: See Institutional Chemical Safety Committee

Institutional Animal Care and Use Committee: Establishes policies for the ethical use and treatment of animal subjects in research projects and reviews all research projects involving animals. In addition, this committee reviews and approves all work in laboratories with particularly hazardous substances.

Institutional Biosafety Committee: Establishes policies related to the safe use of biological and biohazardous materials in the laboratory environment. This includes reviewing and approving guidelines and standard operating procedures and practices for the use and disposal of biohazardous materials.

Institutional Chemical Safety Committee: Establishes policies related to the safe use of chemicals in the laboratory environment. This includes reviewing and approving guidelines and standard operating procedures and practices for the use and disposal of chemicals.

Institutional Review Board: Establishes policies for the ethical use and treatment of human subjects in research projects and reviews all research projects involving humans.

Instructors and Teaching Directors: The primary individual responsible for the operation of teaching laboratories. Ensure that university health and safety policies are adhered to by staff, students, and visitors in teaching laboratories.

IRB: See Institutional Review Board

Laboratory: An area where hazardous materials are used, and the use of these materials meets the definition of laboratory scale and use as noted below.

Laboratory Scale: Means 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 Standard: The OSHA regulation detail in 29 CFR 1910.1450 and appendices that covers laboratory use of hazardous materials occurring on a laboratory scale.

Laboratory Use of Hazardous Materials: means handling or use of such materials in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a "laboratory scale;"

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

NFPA: National Fire Protection Association

Online Web-based Learning: The online platform used by the University for web-based safety training and training record retention.

OSHA: Occupational Safety and Health Administration

OWL: See Online Web-based Learning

Personal Protective Equipment: Attire (such as gloves, lab coats, eyewear, etc.) that is worn to afford protection from hazardous materials.

PI: See Principal Investigator

PPE: See Personal Protective Equipment

Principal Investigator: A Principal Investigator is the primary individual responsible for the preparation, conduct, and administration of a research grant, cooperative agreement, training or public service project, contract, or other sponsored project in compliance with applicable laws and regulations and institutional policy governing the conduct of sponsored research. For purposes stated in this document, the PI is also responsible for ensuring that university health and safety policies are adhered to in their laboratory.

Protective Laboratory Practices and Equipment: means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals. This includes, but is not limited to, engineering controls, administrative controls, and personal protective equipment.

Radiation Use Committee: Establishes policies related to the safe use of radiation and lasers in the laboratory environment. This includes reviewing and approving guidelines and standard operating procedures and practices for the use of radiation and lasers and disposal of radioactive materials.

Responsible Individual: Includes faculty, lab directors, principal investigators, instructors, supervisors and all other individuals who are the primary parties responsible for ensuring that university health and safety policies are adhered to in their laboratory.

RUC: See Radiation Use Committee

SAA: See Satellite Accumulation Area

Safety Data Sheet: A 16 section standardized document provided by manufacturers or suppliers of hazardous materials that communicates the hazards and properties, precautionary measures, emergency response, waste disposal and other important information associated with the material.

SDS: See Safety Data Sheet

Satellite Accumulation Area: The designated location within each laboratory or studio space where hazardous waste is accumulated. There may be more than one satellite accumulation area per laboratory, however, each area must be clearly defined, labeled, and have an inspection sheet that is filled out weekly.

SOP: See Standard Operating Procedure

Standard Operating Procedure: A documented procedure developed from a documented risk assessment.

Supervisors: As directed by the PI, faculty or director, the supervisor is responsible for ensuring that all university health and safety policies are adhered to in their areas.

Working Containers: (1) For a hazardous material: a container to which a virgin hazardous material or mixture containing at least one hazardous material is transferred; (2) For a hazardous waste: a container at the point of generation that is used to initially contain hazardous waste. These containers must be emptied into appropriate hazardous waste storage containers in the SAA whenever work is complete.

Appendix B: GHS Hazard Classes and Definitions

Qualitative definitions of the GHS hazard classes are given below along with the various applicable categories. The lower numbered categories always represent the highest level of hazard (*e.g.,* For a particular route of exposure, Acute Toxicity, category 1 is more toxic than Acute Toxicity, category 4.) The hazard classes and categories a particular hazardous material is assigned to can be obtained from the material's Safety Data Sheet (SDS). More detailed definitions of the hazard classes listed below, including quantitative criteria, are given in Appendices A and B of 29 CFR 1910.1200.

Acute Toxicity: Adverse effects that arise after short duration exposures of small doses to a particular substance. Route of exposure (oral, dermal, inhalation) must be specified. Categories 1-4.

Skin Corrosion/Irritation: Damage resulting to skin from short term exposure to a particular substance. Corrosion designates irreversible damage, while Irritation designates reversible damage. Categories 1A-C designate Corrosion; Category 2 designates Irritation.

Serious Eye Damage/Irritation: Tissue damage or changes in the eye resulting from single exposure of the eye to a particular substance. Eye Damage indicates irreversible tissue destruction or impairment of vision, and is denoted at Category 1. Eye Irritation indicates a reversible change in the eye, and is denoted by Categories 2A-B.

Respiratory Sensitizer: A chemical that will lead to hypersensitivity of the airways following inhalation of the chemical. Initial exposure creates an induction phase and subsequent exposures create an elicitation phase where immunological response is observed. Categories 1A-B.

Skin Sensitizer: A chemical that will lead to allergic response following skin contact. Initial exposure creates an induction phase and subsequent exposures create an elicitation phase where immunological response is observed. Categories 1A-B.

Germ Cell Mutagenicity: Chemicals which may cause mutations in the germ cells of humans that may be transmitted to progeny. Categories 1A-B, 2.

Carcinogenicity: Chemicals which induce cancer or increase its incidence. Categories 1A-B, 2.

Reproductive Toxicity: Adverse effects on sexual function and fertility in adult humans and/or on the development of offspring produced by exposure to a particular chemical. Categories 1A-B, 2.

Specific Target Organ Toxicity-Single Exposure: Specific, non-lethal organ toxicity resulting from a single exposure to a particular chemical. The target organ is generally specified along with route of exposure. The effects can be either irreversible or reversible. Categories 1-3.

Specific Target Organ Toxicity-Repeated or Prolonged Exposure: Specific target organ toxicity arising from repeated exposure to a particular chemical. The target organ is generally specified along with route of exposure. The effects can be either irreversible or reversible. Categories 1-2.

Aspiration Hazard: May cause chemical pneumonia, varying degrees of pulmonary injury or death following aspiration. Aspiration is entry of a particular liquid or solid chemical directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system that is initiated in the time to take one breath. Category 1.

Explosives: A chemical capable of reacting by itself to produce enough gas and/or energy to cause damage to surroundings. Division 1.1-1.6.

Flammable Gases: A gas that can mix with air in small quantity to produce a flammable mixture. Categories 1-2.

Oxidizing Gases: Any gas which contributes to the combustion of materials more than air does. Category 1.

Gases Under Pressure: Includes compressed gases, liquefied gases, refrigerated liquefied gases, and dissolved gases.

Flammable Liquids: Liquids with vapor concentrations near the surface of the liquid capable of igniting at low temperatures (93°C or less). Categories 1-4.

Flammable Solids: Solids capable of being easily ignited by an ignition source such as an open flame or friction. Categories 1-2.

Flammable Aerosols: Non-refillable, pressurized container that contains a flammable liquid, gas or solid. Categories 1-2.

Self-Reactive Chemicals: Thermally unstable chemicals which are capable of undergoing a strong exothermic decomposition even in the absence of oxygen. Categories A-G.

Pyrophoric Liquids: A liquid that is capable of igniting in contact with air. Category 1.

Pyrophoric Solids: A solid that is capable of igniting in contact with air. Category 1.

Self-Heating Chemicals: Reacts with air without a source of energy to produce heat, but will not ignite readily. Categories 1-2.

Chemicals Which, In Contact With Water, Emit Flammable Gases: React with water to become spontaneously flammable or to give off flammable gases in dangerous quantity. Categories 1-3.

Oxidizing Liquids: Liquids which may contribute to the combustion of other materials. Categories 1-3.

Oxidizing Solids: Solids which may contribute to the combustion of other materials. Categories 1-3.

Organic Peroxides: Organic compounds that contain a peroxide (O-O) bond. Peroxides may be unstable and undergo strong exothermic decompositions triggered by friction or shock. Categories A-G.

Corrosive To Metals: A chemical which can react with metals to damage or destroy them. Category 1.

Appendix C: Hazard Assessment for Newly Synthesized Materials

Principal Investigator:

Responsible Laboratory Personnel:

Name of Material:

CAS Number:

Molecular Structure or General Formula:

Please provide the following information for each literature search: date of search, databases used, search criteria, and summary of results including citations. Attach additional pages if necessary. Please provide copies of any documents that are not immediately available online.

If the initial search of the compound yielded no results, please include a literature search for the class of compound or similar compounds for which data is available. Attach additional pages if necessary.

Please keep on file in the laboratory and submit to Environmental Health and Safety

Appendix D: References and Additional Information

Regulations

Department of Homeland Security, Chemical Facility Antiterrorism Standards:
https://www.dhs.gov/chemical-facility-anti-terrorism-standards

Department of Justice, Drug Enforcement Agency, Controlled Substances:
https://www.deadiversion.usdoj.gov/21cfr/cfr/index.html

Department of Transportation, Shipment of Hazardous Materials (49 CFR 171-177):
https://www.ecfr.gov/cgi-bin/text-idx?SID=fd1e0676d45e674dd8b69be61373b41e&mc=true&tpl=/ecfrbrowse/Title49/49cfrv2_02.tpl#0

Environmental Protection Agency Hazardous and Non-Hazardous Waste Regulations:
https://www.epa.gov/rcra/resource-conservation-and-recovery-act-rcra-regulations

Massachusetts Controlled Substances Regulations:
https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXV/Chapter94c

Massachusetts Department of Environmental Protection:
https://www.mass.gov/service-details/waste-recycling-laws-rules

Massachusetts Department of Labor:
https://www.mass.gov/topics/workplace-injuries-illnesses

Massachusetts Department of Public Health, Medical Waste Regulations:
https://www.mass.gov/regulations/105-CMR-48000-state-sanitary-code-chapter-viii-storage-and-disposal-of-infectious-or

Massachusetts Right To Know:
https://www.mass.gov/regulations/105-CMR-67000-right-to-know

Massachusetts Fire Code:
https://www.mass.gov/regulations/527-CMR-100-massachusetts-comprehensive-fire-safety-code

Massachusetts Plumbing Code:
https://www.mass.gov/review-248-cmr-1000-uniform-state-plumbing-code

Massachusetts Building Code:
https://www.mass.gov/ma-state-building-code-780-cmr

Occupational Safety and Health Administration, Hazard Communication Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099

Occupational Safety and Health Administration, Laboratory Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106

Occupational Safety and Health Administration, Respiratory Protection Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12716

Occupational Safety and Health Administration, Access to Employee Exposure and Medical Records:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10027

Occupational Safety and Health Administration, Personal Protective Equipment Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9777&p_table=STANDARDS

Occupational Safety and Health Administration, Eye and Face Protection Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9778

Occupational Safety and Health Administration, Hand Protection Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9788

Occupational Safety and Health Administration, Lockout/Tagout:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9804

Occupational Safety and Health Administration, Occupational Noise Exposure Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9735

Occupational Safety and Health Administration, Compressed Gas Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9747

Occupational Safety and Health Administration, Electrical Safety Standards (Subpart S):
https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910

Occupational Safety and Health Administration, Walking-Working Surfaces Standards (Subpart D):
https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910

Occupational Safety and Health Administration, Emergency Action Plan Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9726&p_table=standards

Occupational Safety and Health Administration, Fire Prevention Plan Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12887

Occupational Safety and Health Administration, Fall Protection Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=1291

Occupational Safety and Health Administration, Confined Space Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9797

Occupational Safety and Health Administration, Medical and First Aid Standard:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9806

Occupational Safety and Health Administration, Portable Fire Extinguishers:
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9811

Occupational Safety and Health Administration, Machinery and Machine Guarding (Subpart O):
https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910

Occupational Safety and Health Administration, Power Tools and Handheld Equipment (Subpart P):
https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910

Occupational Safety and Health Administration, Welding, Cutting, Brazing (Subpart Q):
https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910

OSH Act of 1970 (Section 5 contains the General Duty Clause):
https://www.osha.gov/laws-regs/oshact/section5-duties

Toxicological Databases and Exposure Limits

ACGIH: https://www.acgih.org/forms/store/ProductFormPublic/2019-tlvs-and-beis

ATSDR: https://www.atsdr.cdc.gov/

Haz-Map: https://hazmap.nlm.nih.gov/

Household Products: https://hpd.nlm.nih.gov/

IARC: https://www.iarc.fr/

NIOSH Pocket Guide: https://www.cdc.gov/niosh/npg/

NIOSH: https://www.cdc.gov/niosh/topics/chemical.html

OSHA: https://www.osha.gov/dsg/annotated-pels/

TOXNET: https://toxnet.nlm.nih.gov/

General Resources

ACS, Hazard Assessment In Research Laboratories:
https://www.acs.org/content/acs/en/about/governance/committees/chemicalsafety/hazard-assessment.html

ACS, Identifying and Evaluating Hazards In Research Laboratories:
https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/identifying-and-evaluating-hazards-in-research-laboratories.pdf

ACS, Safety in Academic Chemistry Laboratories, 8th ed.:
https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf

ACS, Guidelines for Chemical Laboratory Safety in Academic Institutions:
https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/acs-safety-guidelines-academic.pdf

ACS, Creating Safety Cultures in Academic Institutions:
https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/academic-safety-culture-report.pdf

ACS, Less is Better, Guide to Waste Minimization:
https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/less-is-better.pdf

Cornell University, EH&S safety videos:
https://www.youtube.com/user/CornellEHS

CSB, Safety and Accident Investigation Videos:
https://www.csb.gov/videos/

NAS, Chemical Laboratory Safety and Security:
http://dels.nas.edu/resources/static-assets/bcst/miscellaneous/Chemical-Laboratory-Safety-and-Security.pdf

Northwestern University, ORS videos:
https://vimeo.com/nuors/videos

NRC, Prudent Practices in the Laboratory, 2011 update:
https://www.nap.edu/catalog/12654/prudent-practices-in-the-laboratory-handling-and-management-of-chemical

NRC, Safe Science: Promoting a Culture of Safety In Academic Research:
https://www.nap.edu/read/18706/chapter/1

NIOSH, School Chemistry Lab Safety Guide:
https://www.cdc.gov/niosh/docs/2007-107/pdfs/2007-107.pdf

NIOSH, Nanotechnology Website:
https://www.cdc.gov/niosh/topics/nanotech/

NSTA, Science Teacher Resources:
http://www.nsta.org/safety/

OSHA, Laboratory Safety:
https://www.osha.gov/pls/publications/publication.athruz?pType=Industry&pID=117

UC Center for Lab Safety Videos:
https://cls.ucla.edu/resources/video-library

UCSD safety videos:
http://blink.ucsd.edu/safety/research-lab/laboratory/videos.html

UN, Guide to GHS:
https://www.osha.gov/dsg/hazcom/ghsguideoct05.pdf

Hill, R. H.; Finster, D.C. *Laboratory Safety for Chemistry Students*, 2nd ed.; Wiley: Hoboken, 2016.

Appendix E: Laboratory Self-Assessment

Laboratory Information
Laboratory Director/ Principal Investigator:
Location:

	Yes	No	N/A	Comments
Training and Documentation				
Up-to-date inventory maintained for all hazardous materials?				
Chemical Safety Data Sheets (SDS) maintained and readily available at all times employees are present?				
Lab Specific Chemical Hygiene Plan in place with specific and appropriate emergency action plans?				
Hazard Assessments (SOPs) are conducted and documented?				
Employees know the location of chemical inventory, SDS and related reference material?				
Employees received institutional safety training (provided by EHS) and supplemental laboratory specific safety training for the hazards present in the laboratory (provided by the lab and documented)?				
Employees familiar with physical and health hazards of chemicals in work areas?				

	Yes	No	N/A	Comments
Employees able to describe how to detect the presence or release of hazardous materials?				
Employees know how to protect themselves and others from the effects of hazardous materials?				
Employees familiar with Chemical Hygiene Plan (institutional and lab specific)?				
Spill and Emergency Planning				
Employees familiar with the fire safety and building evacuation procedures including evacuation routes, nearest fire exits, fire alarm pull stations, and fire extinguishers?				
Emergency procedures and phone numbers clearly posted?				
First aid materials readily available?				
Are any “antidotes” or special first aid materials required and available (eg., Hydrofluoric acid requires calcium gluconate)?				
Spill cleanup materials available and laboratory staff familiar with their use?				
Safety shower, eye wash, electrical panels, other shut offs accessible and unobstructed?				
Safety shower tested and documented within past six months?				
Eye wash tested, flushed and documented at least weekly?				

	Yes	No	N/A	Comments
Fire alarm pull stations and fire extinguishers unobstructed and visible?				
Exits clearly marked?				
Hazard Mitigation Techniques				
Procedures reviewed to include substitution of less hazardous materials where possible?				
Personnel wear shoes that fully cover feet and full length clothing to protect legs?				
Long hair confined? Jewelry, lanyards and other loose articles are confined or removed?				
Lab coats of appropriate material are available and worn when appropriate/necessary?				
Appropriate gloves available and worn when appropriate/necessary?				
Goggles, safety glasses, face shields, etc. are of appropriate type and worn when appropriate/necessary?				
Respirators available and used in the laboratory if necessary? If yes…				
Respirator training, fit test and medical evaluation completed for lab personnel?				
Respirators cleaned, stored appropriately, and inspected regularly?				

	Yes	No	N/A	Comments
Chemical Fume Hood available and used when necessary? If yes…				
Chemical fume hood free of clutter?				
Chemical fume hood inspected within last 12 months and working height indicated?				
Compatible chemicals and quantities used (eg., perchloric acid use may require a specialized fume hood).				
Chemical Safety				
Are chemicals used in this area? If yes…				
Chemical inventory management/ordering system in place and checked before ordering new chemicals?				
Appropriate labels (including the full name of the material, no abbreviations, and hazard indication) are found on all hazardous chemical containers?				
Containers are in good condition (eg., labels intact, metal cans free of rust) and closed when not in use?				
Containers properly segregated by hazard class (eg., flammables away from oxidizers, acids separated from bases, incompatible acids separated, etc.)?				

	Yes	No	N/A	Comments
Storage of chemicals above eye level is avoided when possible? Corrosive chemicals are not stored above eye level?				
Flammable liquids stored in OSHA/NFPA approved cabinets and safety containers?				
Flammable liquids requiring refrigeration stored in either explosion proof or flammable resistant refrigerators and freezers?				
Ignition sources avoided when using/storing flammables?				
Concentrated liquid corrosives stored in acid cabinets or other appropriate storage?				
Peroxide formers labeled and tested in the last 3 months?				
Picric acid sufficiently wet?				
Large containers (4L or greater) stored near the floor?				
Bottle carriers or carts utilized when transporting hazardous chemicals between work areas?				
Proper signs delineate designated areas where high hazard chemicals are used?				
Designated area properly cleaned and decontaminated?				
Compressed and Cryogenic Gas Safety				

	Yes	No	N/A	Comments
Are compressed gas cylinders used in this area? If yes…				
Cylinders stored upright and properly secured at all times?				
Caps properly secured when cylinders are not in use?				
Regulators always used, proper regulators used for type of gas?				
Cylinders in good condition and clearly marked?				
Flammables stored separately from oxidizers, toxics in secure area, etc?				
Flammable gases in gas cabinet if required?				
Cylinders moved on appropriate carts with regulators removed and caps secured?				
Cylinders of toxic gases stored in ventilated enclosures? NFPA Health Rated 3 or 4 gases larger than lecture bottles must be in gas cabinets. Flow restrictors in use? Appropriate tubing connections?				
Cryogenic gas cylinder pressure relief valve in proper working order?				
Oxygen monitor available in areas with increased likelihood of oxygen deficient or enriched atmospheres?				
Equipment and Physical Hazards Safety				
Are equipment safety signs posted and in good condition?				

	Yes	No	N/A	Comments
Are all guards and shields in place and secured?				
Are safe work practices (long hair tied back, no loose clothing, etc.) being adhered to by all equipment users?				
Is equipment in good repair with evidence of proper maintenance?				
Are electrical cords in good condition, out of travel paths, and free of any cracks or breaks in insulation?				
Is a lock-out, tag-out program in place if appropriate?				
Is proper PPE available and being used by equipment operators?				
Is a tagging system in place to prevent use of damaged equipment?				
Is access to the equipment restricted?				
Have all users been trained to operate equipment? If not, is there a record of who is approved to use specific equipment?				
Have there been any modifications to the equipment?				
Is equipment being used appropriately (i.e., not for task for which it is not designed)?				
General Laboratory Safety				
Smoking, eating and drinking is prohibited in the lab? No food storage in the lab?				

	Yes	No	N/A	Comments
Lab is maintained secure; door is locked when no one is in the lab?				
Appropriate warning signs posted near lab entrance?				
Unobstructed aisles maintained at least 36 inches wide throughout?				
Lab benches and work areas free of clutter?				
Shelves and cabinets in good condition?				
Storage above eye level minimized?				
Refrigerators and freezers clearly labeled as not for food use?				
Waste Management				
Solid wastes are identified and discarded appropriately?				
Is universal waste generated in this area? If yes…				
Mercury containing lamps and unwanted electronics recycled?				
Equipment decontaminated prior to disposal as appropriate?				
Is hazardous waste generated in this area? If yes…				
Waste containers closed unless actively adding or removing waste?				
SAA located at or near point of generation?				

	Yes	No	N/A	Comments
Maximum SAA storage capacity not exceeded (55 gallons for non-acutely hazardous waste; 1 kg or 1 quart for actutely hazardous waste)?				
Waste containers are in good condition (not leaking, rusted, bulging or damaged)?				
Each waste container is marked with the words "Hazardous Waste"?				
Each waste container is marked with full chemical names identifying the contents stored inside (no abbreviations or formulas)?				
Add least one characteristic hazard (i.e., ignitable, corrosive, reactive, toxic) is indicated on the label?				
Each waste container is in good condition and not leaking?				
Each waste container is in secondary containment, which is in good condition?				
Only waste containers with compatible contents are stored in the same secondary containment?				
Once a waste container is full, a hazardous waste pick up request is submitted? No two containers have the exact same contents?				
Full waste containers are removed within three calendar days?				
Area is inspected weekly and documented?				

	Yes	No	N/A	Comments
Empty chemical containers are tripled rinsed and discarded with caps off?				
Are sharps waste generated in this area? If yes…				
Sharps are discarded into an appropriate puncture resistant container or stored appropriately?				
Sharps waste containers are red, red-orange or fluorescent orange in color to comply with 105 CMR 480?				
Sharps containers are not overfilled and are removed when filled?				

Appendix F: High Energy Oxidizers

Listed here is a *partial* list of the most commonly found oxidizing compounds used in the laboratory. Most of *these compounds would form explosive mixtures with combustibles, organics or other easily oxidizable materials.* Keep in mind that these are specific examples of representative classes of materials that possess such properties (i.e., all nitrate, perchlorate, chlorate, permanganate salts are good oxidizers).

Additional Safety information should be obtained from SDSs and other reference material before proceeding with work involving these compounds.

- Ammonium perchlorate (NH_4ClO_4)
- Ammonium permanganate (NH_4MnO_4)
- Barium peroxide (BaO_2)
- Bromine (Br_2)
- Calcium chlorate ($Ca(ClO_3)_2$)
- Calcium hypochlorite ($Ca(ClO)_2$)
- Chlorine trifluoride (ClF_3)
- Chromium trioxide (CrO_3)
- Dibenzoyl peroxide ($(C_6H_5CO)_2O_2$)
- Fluorine (F_2)
- Hydrogen peroxide (H_2O_2)
- Magnesium perchlorate ($Mg(ClO_4)_2$)
- Nitric acid (HNO_3)
- Nitrogen peroxide (in equilibrium with nitrogen dioxide) N_2O_4; NO_2
- Perchloric acid ($HClO_4$)
- Potassium bromate ($KBrO_3$)
- Potassium chlorate ($KClO_3$)
- Potassium perchlorate ($KClO_4$)
- Potassium Permanganate ($KMnO_4$)
- Potassium peroxide (K_2O_3)
- Propyl nitrate ($CH_3\ (CH_2)_2\ NO_3$)
- Sodium chlorate ($NaClO_3$)
- Sodium chlorite ($NaClO_2$)
- Sodium perchlorate ($NaClO_4$)
- Sodium peroxide (Na_2O_2)

Appendix G: Shock Sensitive Materials

Listed here is a *partial* list of potentially shock sensitive compounds.

Additional Safety information should be obtained from SDSs and other reference material before proceeding with work involving these compounds.

- 2,4-dintrophenylhydrazine (when dry)
- Compounds with high nitrogen content
- Compounds with high oxygen content
- Heavy metal acetylide compounds
- Heavy metal azide compounds
- Heavy metal fulminate compounds
- Heavy metal salts of perchlorates, particularly when made anhydrous by heating
- Nitrogen trichloride
- Nitrogen triiodide
- Nitroglycerin
- Organic Peroxides
- Peroxides formed by peroxide forming materials
- Picrate salts
- Picric acid (when dry)

Appendix H: Common Peroxide Forming Materials

In general, any material which can readily form stable free radicals is also a good candidate to be a peroxide forming material. Examples include compounds that: (1) contain benzylic, allylic or tertiary hydrogen, (2) are alkyl ethers, (3) are secondary alcohols, (4) are cyclohexanes, (5) are alkynes or amides with α -carbon hydrogen. All peroxide forming materials must be tested for peroxides once every three months.

Class A: Chemicals that form explosive levels of peroxides without concentration

Isopropyl ether	Sodium amide (sodamide)
Butadiene	Tetrafluoroethylene
Chlorobutadiene (chloroprene)	Divinyl acetylene
Potassium amide	Vinylidene chloride
Potassium metal	

Class B: These chemicals are a peroxide hazard on concentration (distillation/evaporation). A test for peroxide should be performed if concentration is intended or suspected.

Acetal	Ethylene glycol dimethyl ether (glyme)
Cumene	Furan
Cyclohexene	Methyl acetylene
Cyclooctene	Methyl cyclopentane
Diaacetylene	Methyl-isobutyl ketone
Dicyclopentadiene	Tetrahydrofuran
Diethylene glycol dimethyl ether (diglyme)	Tetrahydronaphthalene
Diethyl ether	Vinyl ethers
Dioxane (*p*-dioxane)	

Class C: Unsaturated monomers that may autopolymerize as a result of peroxide accumulation of inhibitors have been removed or depleted.

Acrylic acid	Styrene
Butadiene	Vinyl acetate
Chlorotrifluoroethylene	Vinyl chloride
Ethyl acrylate	Vinyl pyridine
Methyl methacrylate	

These sources are illustrative, not comprehensive.

Reference: *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*. National Research Council Committee on Hazardous Substances in the Laboratory. National Academy Press, Washington, D.C. (2011).

Appendix I: Template for Laboratory Specific Chemical Hygiene Plan

Please see the EH&S website for the current template: https://ehs.umass.edu/lab-specific-chemical-hygiene-plan-template

Appendix J: Prior Approval For Hazardous Laboratory Operations

PRIOR APPROVAL FOR HAZARDOUS LAB OPERATIONS UNIVERSITY OF MASSACHUSETTS/AMHERST	
Principal Investigator:	**Department:**
Building / Room: **Specific location:**	**Phone #:** **E-Mail:**
Project Title or Chemical Procedure:	
Description of Chemical Procedure (attach additional pages if necessary)	
Safety Precautions/Equipment:	
Personnel Training:	
Personnel Approved for This Procedure:	
Waste Disposal:	
Emergency Plan:	
Medical Surveillance:	

Name	Title/Department	Signature/Date:
Faculty/Supervisor		
Department Head / Chair		
EH&S		
ICSC Committee		

Appendix K: Chemical Storage Scheme

Chemical Storage Scheme taken from: National Research Council, *Prudent Practices In the Laboratory: Handling and Management of Chemicals*. National Academies Press, 2011. p. 96-97

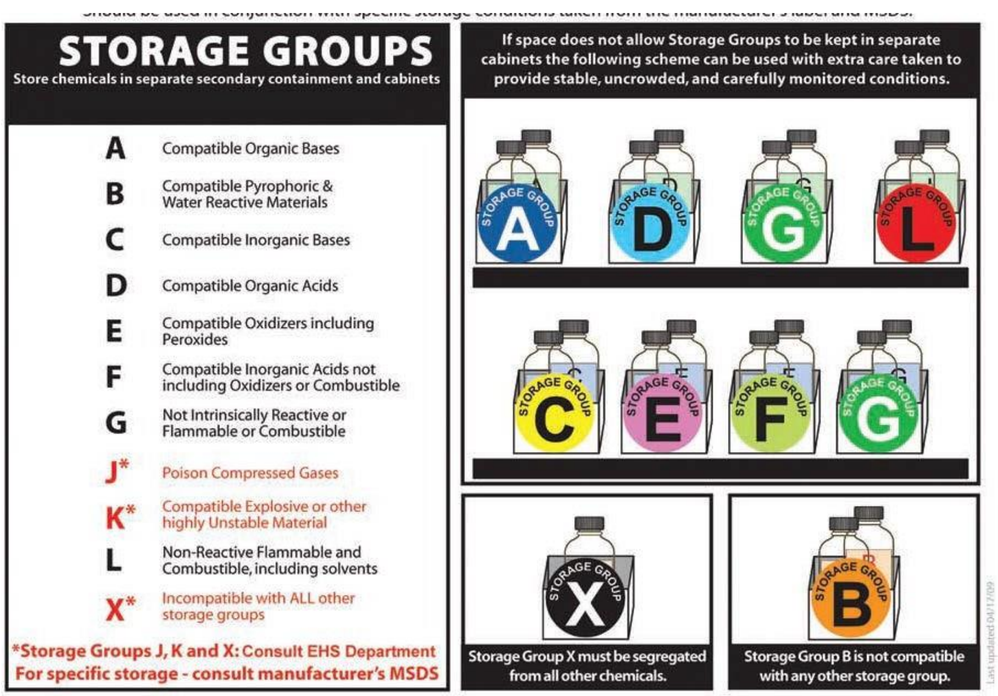


TABLE 5.1 Examples of Compatible Storage Groups

A: Compatible Organic Bases

Diethylamine
Piperidine
Triethanolamine
Benzylamine
Benzyltrimethylammonium hydroxide

B: Compatible Pyrophoric & Water-Reactive Materials

Sodium borohydride
Benzoyl chloride
Zinc dust
Alkyl lithium solutions such as methyl lithium in tetrahydrofuran
Methanesulfonyl chloride
Lithium aluminum hydride

C: Compatible Inorganic Bases

Sodium hydroxide
Ammonium hydroxide
Lithium hydroxide
Cesium hydroxide

D: Compatible Organic Acids

Acetic acid
Citric acid
Maleic acid
Propionic acid
Benzoic acid

E: Compatible Oxidizers Including Peroxides

Nitric acid
Perchloric acid
Sodium hypochlorite
Hydrogen peroxide
3-Chloroperoxybenzoic acid

F: Compatible Inorganic Acids not Including Oxidizers or Combustibles

Hydrochloric acid
Sulfuric acid
Phosphoric acid
Hydrogen fluoride solution

J: Poison Compressed Gases

Sulfur dioxide
Hexafluoropropylene

K: Compatible Explosives or Other Highly Unstable Materials

Picric acid dry(<10% H_2O)
Nitroguanidine
Tetrazole
Urea nitrate

L: Nonreactive Flammables and Combustibles, Including Solvents

Benzene
Methanol
Toluene
Tetrahydrofuran

X: Incompatible with ALL Other Storage Groups

Picric acid moist (10-40% H_2O)
Phosphorus
Benzyl azide
Sodium hydrogen sulfide

Appendix L: Lab Incident Report Form

Name: **Title:**	**Department:** **Building / Room :**
Date/Time of incident:	**Phone #:** **E-Mail:**
Witness(es):	
Description of incident: Include the use of Personal Protective Equipment, chemical hood or other environmental control, safety equipment (attach additional pages if necessary).	
Did the incident result in a an injury: Yes ☐ No ☐ **Description of injury:**	
Notice of Injury report submitted: Yes ☐ No ☐ Date:	
Environmental Health and Safety (EH&S) notified: Yes ☐ No ☐ Date: **Name of EH&S staff person notified:** **Title:** **Date:**	
Emergency response information (include EH&S, fire, police, ambulance response present at the scene):	
Name of supervisor:	**Signature:** **Date:**