Tufts
UNIVERSITY

# Chemical Hygiene Plan

REVIEW BY STEPHEN R. LARSON MS, CSP, CIH, RBP, RRPT

TUFTS ENVIRONMENTAL HEALTH AND SAFETY
JANUARY 2019

# Executive Summary:

- Responsibility for the safe use of chemicals in the laboratory rests with everyone in the laboratory. The laboratory supervisor/principal investigator has overall responsibility for chemical hygiene in the laboratory.

- Anyone working in the laboratory must complete annual laboratory safety training. This training can be found at: http://publicsafety.tufts.edu/EHS/annual-laboratoryoratory-safety-training/

- Laboratories are required to maintain a chemical inventory that should be updated as new chemicals are added, at least annually.

- Safety Data Sheets (SDS) must be kept in the work areas where hazardous chemicals are in use. All employees should know how to access SDSs for the chemicals they use.

- Avoid bulk purchase of chemicals and order the smallest amount needed for the project. Wherever possible, use existing chemical stocks before purchasing additional chemicals.

- Work in a fume hood when there is a risk of airborne hazards such as dusts, mists, vapors or gases.

- Secondary containers to which hazardous materials are transferred must be labeled with the product identifier/name and applicable hazards. If the container is in use and under the visual control of the user at all times, a written label is not required.

- No eating, drinking, chewing of gum or tobacco, applying cosmetics, taking medication or storing of food or drink in any laboratory area. NOTE: Empty cans or wrappers in trash are evidence of eating.

- Lab coat, gloves and eye protection are standard personal protection equipment (PPE). Every person should have a written PPE assessment identifying the required PPE he or she needs.

- Wash hands after you remove gloves and before you exit the laboratory

- Never use mouth suction to fill a pipet. Use a pipet bulb or other mechanical pipetting device.

- It is permitted to work alone in a laboratory. However, highly hazardous operations may require a mandatory check-in policy. These operations and the details of this policy need to be determined by the lab supervisor or PI.

- Unattended experiments-laboratory lights should be left on, and signs should be posted identifying the nature of the experiment and the hazardous substances in use, and contact information for a responsible person. Make arrangements for other workers to periodically inspect the operation.

- All personnel should be familiar with the use and locations of the nearest safety shower and eyewash station.

- Do not recap hypodermic needles. Use a jig or one hand method if recapping is mandatory.

- Do not store incompatible chemicals together. Read the label and the SDS before storing a chemical.

- Secure compressed gas cylinders in an upright position. Use a cart to move cylinders. Use the correct regulator and always wear safety glasses.

- All emergencies, medical, fire, criminal, and chemical spills must be reported to the University Police at 6-6911 or 617-627-6911

- Every laboratory is equipped with a spill kit. Don't clean up a chemical spill if you feel incapable of doing so. Call your supervisor or a colleague for assistance.

- Peroxide forming chemicals-date containers upon receiving and again upon opening. Follow maximum storage guidelines, either 3 or 12 months.

- High hazard chemicals must have a Safety Plan and be registered with TEHS. The High Hazard Chemical List and Registration form can be found at: http://publicsafety.tufts.edu/EHS/chemical-hygiene/

- Waste containers must comply with Tufts University's Hazardous Chemical Waste Management Plan which can be found at: https://publicsafety.tufts.edu/ehs/environmental-management/hazardous-chemical-waste-management-plan/

- The Satellite Accumulation Area (SAA) should be inspected weekly.

- Don't mix incompatible chemicals in the same waste bottle. Concentrated nitric acid accidentally added to organic waste has resulted in a number of laboratory explosions.

- Administrative practices used to control hazards in the laboratory are; chemical registrations, safety plans, standard operating procedures and annual laboratory inspections by Tufts Environmental Health and Safety (TEHS).

# 1. Introduction

## 1.1 Purpose and Scope

The Occupational Safety and Health Administration (OSHA) of the US Department of Labor enacted the Occupational Exposure to Hazardous Chemicals in Laboratory Standard (29CFR1910.1450) in 1990. The requirements of this standard apply to all employees; however, this plan applies to all personnel (employees, students, visitors) engaged in the laboratory use of hazardous chemicals at Tufts University.

The primary requirement of the standard is the formulation and implementation of the Tufts Chemical Hygiene Plan (CHP) and the development of written Safety Plans for high hazard chemicals. This CHP includes work practices, procedures and policies to ensure that employees are protected from the adverse effects of all potentially hazardous chemicals.

Review and alterations of the CHP are made as needed, but no less than annually.

In this document, a laboratory includes support rooms, equipment rooms and shops used to support laboratory activities.

## 1.2 Roles and Responsibilities

Responsibility for chemical hygiene rests at all levels. Specific responsibilities are as follows.

University Provost - The University Provost has the ultimate legal responsibility and accountability for chemical hygiene within the institution. The University Provost shall:

- Appoint a chemical hygiene officer.
- Designate a signatory person for the University in safety, health, and environmental matters relating to proposals for funds from an outside agency for sponsored work.
- Provide University legal counsel to the Chemical Hygiene Officer and other University employees who have need to consult with counsel on matters related to chemical hygiene.
- Include provisions for appropriate storage and disposal of chemicals in the long- range plans for facilities development.
- Inform the University community of the CHP.
- Provide adequate support for institutional chemical hygiene.
- Respond to reports and or requests regarding matters of chemical hygiene to the appropriate individual.

Deans and Department Chairpersons - In University departments or buildings containing laboratories where potentially hazardous chemicals are used, the Deans and Department Chairpersons shall:

- Confirm Principal Investigators (PIs) & Supervisors have the resources (facility, equipment, training and staffing) to assure their specific research is performed safely and in compliance with regulatory requirements.
- Assure that unsafe practices, accidents or incidents are reported and corrective actions are implemented.

**Principal Investigator (PI)/Supervisor - The PI/Supervisor has overall responsibility for chemical hygiene in the laboratory which includes the responsibility to identify high hazard chemicals in use and storage and register such use with TEHS using the High Hazard Chemical Registration form. In addition, the PI/Supervisor is responsible for:**

- Ensure that laboratory workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided;
- Provide regular, chemical hygiene and housekeeping inspections including routine inspections of emergency equipment;
- Be aware of the current legal requirements concerning regulated substances used in her/his laboratory;
- Determine the required levels of protective apparel and equipment and ensure that workers utilize the equipment and wear the apparel, including eye protection.
- Ensure that facilities and training for use of any material being ordered are adequate.
- Ensure that appropriate signs and notices of hazards and restricted activities are posted in the laboratory.
- Report any chemically-related problems to the appropriate department head to TEHS.

Laboratory Worker - Each laboratory worker is responsible for:

- Planning and conducting each operation in accordance with the practices and procedures described in the CHP.
- Following safe practices at all times during the experiment.
- Informing his/her supervisor of any incident or accident associated with the use or storage of any chemical or chemical waste.

Chemical Hygiene Officer (TEHS) - The Chemical Hygiene Officer shall:

- Work with the campus Laboratory Safety Committees, administrators and other employees to develop and implement appropriate chemical hygiene policies and practices;
- Monitor procurement, use, and disposal of chemicals used in the laboratory by inspecting chemical inventories;
- Ensure audits and inspections are conducted and records maintained;
- Assist laboratory staff in developing adequate safety plans and precautionary techniques;
- Know the current legal requirements concerning regulated substances;
- Recommend improvement to the CHP following chemical incidents and accidents;
- Ensure that the CHP is reviewed annually.

## 1.3 Employee Information and Training

An employee safety training program is available at Tufts University and is reviewed regularly. While there are general training courses provided by TEHS, the PI/Supervisor shall provide task specific training at the time of an employee's initial assignment to a work area where hazardous chemicals or equipment are present and prior to new or additional assignments involving new hazards.

The laboratory training and education program is a regular, continuing activity. The purpose of this training is to assure that employees covered under this program are adequately informed about the work in the laboratory, its risks, how to control the risks and what to do if an accident occurs. Every laboratory worker should know the location and proper use of available personal protective equipment, and emergency equipment and procedures.

No person will work with a chemical unless she or he is knowledgeable of the physical, fire, and health hazards of that chemical (aware of the general information as may be found on the Safety Data Sheet). It is the responsibility of the PI/Supervisor to see that students and staff are properly

trained to handle all toxic or hazardous chemicals used in their research. It is the responsibility of the student and employee to follow these safety procedures so as not to endanger or injure themselves or others.

All handling procedures including spill cleanup shall be designed to avoid direct contact with chemicals. Minor spills can be safely cleaned up by laboratory staff. Major spills should be reported to Tufts University Police Department as outlined in the Tufts Emergency Response Guide.

Careful work habits are to be practiced at all times; any "routine" contact is to be avoided as much as possible. (Remember, not all SDSs or sources of hazard information are complete, and not all chemicals have been thoroughly researched for toxicity. Therefore, all unnecessary exposure should be avoided.)

PIs/Supervisors must provide their staff with Standard Operating Procedures (SOPs) or Safety Plans to follow when working with particularly hazardous chemicals (reactive, carcinogens, poisons, toxins).

The CHP is available online at: http://publicsafety.tufts.edu/ehs/chemical-safety/chp/ and available to employees. Additional literature and consulting advice concerning chemical hygiene are readily available from TEHS. Laboratory personnel are encouraged to use these information resources.

The Tufts Emergency Response Guide can be found at:
http://emergency.tufts.edu/guide/

The Tufts Laboratory Health and Safety webpage can be found at:
https://publicsafety.tufts.edu/ehs/laboratory-safety/

# 2. Hygiene Practices/Standard Operating Procedures (SOPs)

## 2.1 Hazard Communication

**2.1.1 Chemical Inventory** - The University is required to compile and maintain a Chemical Inventory for all chemicals supplied with a Safety Data Sheet. The Chemical Inventory at a minimum contains the following information:

- Chemical name.
- Work area where the chemical is normally used or stored.
- Typical amount of the chemical that is generally on hand.

Laboratories are required to maintain a workplace chemical inventory that is updated as new chemicals are added and reviewed at least annually. TEHS will request a copy of the inventory during the annual Laboratory Safety Inspection.

Whenever possible, use existing chemical stocks before purchasing additional chemicals. When purchasing chemicals, avoid bulk purchase (>5 gal of liquid or 2 kg of solid)
and order the smallest amount needed for the project.

**2.1.2 Labeling -** It is the responsibility of the manufacturer or distributor to label each container of hazardous materials. These labels may not be removed or defaced and must be legible and prominently displayed on the container. Labels at minimum should contain the following required information:

- Identity of the hazardous substance(s), using the full chemical name
- Hazard and precautionary statements
- Name and address of the manufacturer, importer or other responsible party
- Signal word, e.g., danger, warning
- Pictogram

Other information that may be provided on the manufacturer's label includes:

- Synonyms, if any
- First aid procedures

Permanent secondary containers to which hazardous materials are transferred must be labeled with the product identifier/name and applicable hazards. A portable secondary container that is that in use and under the visual control of the user at all times, does not need to be labeled. If the user takes a break and leaves a portable secondary container unattended for a short period of time, the container should be labeled with chemical name and primary hazard.

It is the responsibility of each employee to make sure that the containers of hazardous materials they are using have a label and notify their supervisor if an unlabeled container is found.

Containers of non-hazardous materials (such as water) should be labeled as to their identity. Masking tape or marking on the container is acceptable.

**2.1.3 Safety Data Sheets (SDS) -** A Safety Data Sheet (SDS) provides detailed information on the hazards of a specific chemical and precautions to be taken. It is the responsibility of the manufacturer or distributor to provide an SDS for each hazardous material. The SDS contains information on the following items:

- 1. Identification: Product identifier used on label. Name, address and telephone number of chemical manufacturer. Emergency phone number.
- 2. Hazard Identification: Physical hazards, including potential for fire, explosion, and reactivity. Health hazards.
- 3. Composition/information on ingredients: The identity of the material, including chemical and common names and the hazardous ingredients.
- 4. First-aid measures: Emergency and first aid procedures
- 5. Fire-fighting measures;
- 6. Accidental release measures
- 7. Handling and storage
- 8. Exposure controls/personal protection; Applicable control measures such as engineering controls, work practices, or personal protective equipment.

- 9. Physical and chemical properties; Physical and chemical characteristics, such as vapor pressure and flash point.
- 10. Stability and reactivity; Precautions for safe handling, including hygienic practices, protective measures during repair and maintenance of contaminated equipment, and procedures for cleanup of spills.

- 11. Toxicological information; Health hazards, including symptoms of exposure and medical conditions which may be aggravated by exposure. Information on exposure limits. The primary route(s) into the body. Whether the chemical is listed as an actual or potential carcinogen.

- 12. Ecological information (non-mandatory):
- 13. Disposal consideration (non-mandatory):
- 14. Transport information (non-mandatory):
- 15. Regulatory information (non-mandatory):
- 16. Other information, including date of preparation or last revision: Preparation data of the SDS and the last revisions.

SDSs must be kept in the work areas where hazardous chemicals are and be readily accessible. A shared electronic folder or hardcopies in a 3-ring binder are acceptable assuming they are complete, current and organized so that they can be easily navigated. All employees should be aware of the location of the SDSs for the chemicals they use.

Safety Data Sheets are available by contacting the manufacturer or on-line at the manufacturer's website.

Commercially manufactured, hazardous materials (other than novel compounds) without an SDS should not be used in the laboratory. These materials should be stored until an SDS is obtained or disposed of as hazardous waste.

**2.1.4 Signage -** Areas where hazards or the potential for hazards may exist are conspicuously marked with caution or restricted access signs. Areas consist of, but are not limited to, laboratory, common equipment rooms, and walk-in refrigeration units. Additional signage may be required for small, specific hazard control areas such fume hoods and laboratory benches.

## 2.2 Chemical Classification

The OSHA Hazard Communication regulation defines a hazardous chemical as any element, chemical compound or mixture of elements and/or compounds which is a physical hazard or a health hazard. The Standard applies to all hazardous chemicals regardless of quantity.

A chemical is a physical hazard if there is documented scientific evidence that it is a combustible liquid, a compressed gas, explosive, flammable, organic peroxide, an oxidizer, a pyrophoric compound, an unstable material (reactive) or water reactive substance.

A chemical is a health hazard if there is documented scientific evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees.

Hazardous chemicals are classified as: asphyxiants, carcinogen, flammable and combustible chemicals, irritants, reproductive toxins, sensitizers and reactive chemicals such as pyrophoric liquids or water reactive chemicals.

## 2.3 Personal Protection

### 2.3.1 Chemical Fume Hoods (Laboratory Hoods)

In a laboratory where workers are at risk of significant exposure to potentially hazardous airborne chemicals there should be at least one chemical fume hood for every 2 workers. Hoods should be large enough to provide each person with 2.5 linear feet of working space at the face.

Each hood should have a continuous airflow monitoring device to allow direct monitoring of adequate hood performance by the operator. This device should have a battery backup. A length of tissue paper taped to the sash bottom can be used to supplement this meter. Certification of

fume hood operation will be conducted annually by a qualified contractor.

Note: Chemical fume hoods which recirculate exhaust air back to the laboratory environment through filters should be used with extreme caution. Adsorbents and filters used may not adequately remove contaminants from the exhaust air. Such filters can get easily overloaded with air contaminants. Contact the Chemical Hygiene Officer for advice.

More information on fume hoods can be found at:
https://publicsafety.tufts.edu/ehs/laboratory-safety/fume-hoods/

**2.3.2 Glove Boxes**
Glove boxes have multiple ports in which the employee operates using mounted arm-length rubber or protective gloves. They are generally operated under negative pressure, so that any air leakage is into the box. If the material being used is sufficiently toxic to require the use of a negative pressure glove box, then the exhaust air will require treatment. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers, filters or given other treatment before it is released into the environment.

Glove boxes, used for experiments where protection from atmospheric humidity or oxygen is desired, commonly operate under ambient or positive pressure. If positive pressure glove boxes must be used with highly hazardous chemicals, they should be thoroughly tested for leaks before each use, and there should be a method of monitoring the integrity of the system such as a pressure gauge. Certification of glove box operation will be conducted annually by a qualified contractor. Consult with TEHS for a list of qualified contractors.

**2.3.3 Other Local Ventilation Devices**
Ventilated storage cabinets (gas cabinets), canopy hoods, flexible snorkels, etc. should be provided as needed and can replace a laboratory hood in some applications. Canopy hoods, snorkels and other large local exhaust devices should not be installed on existing ventilation systems without the approval of TEHS.

**2.3.4 Personal Protective Equipment**
Personal protective equipment is any device or clothing worn/used by the worker to prevent contact with a hazardous chemical. They are to be used only where engineering and administrative controls cannot be used or are inadequate, or while controls are being implemented.

The Safety Data Sheet (SDS) will list the personal protective equipment recommended for use with the chemical. The SDS addresses “worst case” conditions. Therefore, all the equipment shown may not be necessary for a specific job. Your supervisor or TEHS will determine which personal protective devices are required for each task. There is no harm in being overprotected. Departments must provide personal protective equipment to employees at no cost to the employee.

Use required personal protective equipment as identified in a written PPE Assessment.

See TEHS Personal Protection Plan at:
http://publicsafety.tufts.edu/ehs/ppe/
Deans, Directors, Department Chairs, Department Managers, Principal Investigators and supervisors at Tufts University must review the Tufts University Personal Protective Equipment Plan.

They shall complete the ***Certification of Hazard Assessment and Personal Protective Evaluation*** *(Hazard Assessment Form)*, found in Appendix A.

They must also train employees in personal protective equipment and complete the ***Tufts University's Record of Training form***, found in Appendix B

Tufts respiratory protection program can be found at:
http://publicsafety.tufts.edu/ehs/ppe/respiratory-protection-program/ Inspect gloves before use. Insure that the proper type of glove is used for your experiment. Nitrile are good general chemical resistant gloves. Latex are better suited for biological work. Check glove manufacturer's glove guides and permeability rates.

Glove permeation guides are available at:
http://publicsafety.tufts.edu/EHS/chemical-resistant-glove-guide/

**2.3.5 General Hygiene Practices**
All persons should know the operating, handling and emergency procedures for their particular work area. All personnel should know the locations of safety equipment, such as telephones, safety showers and eyewash stations, fire blankets, fire extinguishers and fire alarms and the locations of restricted areas. They should also know the locations of and procedures for obtaining safety information and SDSs. All new personnel entering a laboratory for the first time shall be instructed regarding the same before beginning work.

Eating, Drinking and Smoking-There shall be no eating, drinking or evidence of eating and drinking, smoking, chewing of gum or tobacco, applying cosmetics, taking medication or storing food or drink in any laboratory area.

Do not dispense more of a hazardous chemical than is needed for immediate use.

Always use chemicals in areas with adequate ventilation. Chemicals with harmful vapors should only be used in fume hoods or other enclosures vented to the outside. Some biosafety cabinets and glove boxes do not meet this requirement.

Use hazardous chemicals only as directed or for their intended purpose.

Inspect equipment or apparatus for electrical or mechanical damage before using with a hazardous chemical. Do not use damaged equipment.

Never use mouth suction to fill a pipet. Use a pipet bulb or other mechanical pipetting device.

Keep laboratory doors closed. When the lab is unoccupied, ensure the lab doors are locked.

Perform routine hand washing after you remove gloves and before you exit the laboratory. Hand washing safeguards against exposure to toxic chemicals or biological agents.

Laboratory clothing-Loose fitting clothes should be restrained by a laboratory coat and long hair should be tied back. Open toed shoes and shorts are prohibited because there are no clothing barriers to prevent skin contact.

Working alone in the laboratory-It is not prudent to work alone in a laboratory. The OSHA

Laboratory Standard states “Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous.” Accidents are unexpected by definition, and if a person is working alone when one occurs, his or her ability to respond appropriately could be severely impaired, which could result in personal injury or death and catastrophic facility damage. Thus, it is imperative that, whenever working in the laboratory, others are actively aware of your activities.

If faced with a situation where you feel it is necessary to work alone in a laboratory. Reconsider the need. Are the increased risks to your health and safety really outweighed by the return? If so, is there anyone else within the building who could act as a “buddy” to check on you periodically during the time that you feel you must work alone? If the timing of the task cannot be changed and you still feel it must be accomplished during a period when the laboratory is empty, is there any other person trained in laboratory procedures who can accompany you while you work?

Unattended experiments- Laboratory operations involving hazardous substances are sometimes carried out continuously or overnight with no one present. Reconsider the timing and setup of the work. Is there any way to accomplish the required tasks during a time when others will be present? If not, it is the responsibility of the worker to design these experiments so as to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas. Laboratory lights should be left on, and signs should be posted identifying the nature of the experiment and the hazardous substances in use. If appropriate, arrangements should be made for other workers to periodically inspect the operation. Information should be posted indicating how to contact the responsible individual in the event of an emergency.

Housekeeping - Floors should be cleaned regularly. Laboratory benches should be cleaned after use. Absorbent liners/pads that have been contaminated should be replaced. Storage areas should be available for all supplies and small equipment. Egress pathways should be free of obstructions at all times.

Discarding of protective equipment-protective garments and gloves are not to leave the laboratory/workplace and are prohibited in public areas such as hallways, elevators and break rooms.

## 2.4 General Laboratory Safety

**2.4.1 Autoclaves -** Autoclaves work at high temperature and high steam pressure. Open autoclave doors slowly, standing to one side, to prevent burn from residual steam. Wear heat resistant gloves when removing hot items.

**2.4.2 Bunsen Burners and Heating Equipment -** Bunsen burners and heating equipment should be used with extreme caution. They serve as ignition sources in laboratory environments where the presence of flammable and combustible materials is commonplace. Therefore, proper equipment setup and location, along with safe work practices, are essential. Note: Whenever possible, replace Bunsen burners with electric heat mantles to insure even heat control and eliminate open flame and gas sources.

- The open flames and heat from the burners must not be in close proximity to flammable, reactive, toxic and combustible materials and compressed gases.
- Do not use Bunsen burners in Biosafety Cabinets (See Tufts University Biosafety Manual)
- Check tubing for damage before use. Securing the tube connections with clamps is recommended.

- Maximum tube lengths cannot exceed six feet. Use only natural rubber tubing or braided metal. Do not use Tygon tubing.
- Use safety lighters, not matches, to light gas burners.
- Never leave Bunsen burners unattended.
- Heat flammable, combustible and strong oxidizing materials such as perchloric acid with electric heating mantles, not Bunsen burners.
- Equip all unattended electrical apparatus with a manual reset over-temperature limit switch, in addition to normal temperature controls.
- Equip heating apparatus with circulation fans with an interlock arranged to disconnect the heating elements when the fan is inoperative.
- Make sure oven and furnace installations comply with NFPA 86A, Standard for Ovens and Furnaces. Call the Fire Marshal for further information.

**2.4.3 Laboratory Hoods -** aka Chemical Fume Hoods should be utilized to avoid exposure to toxic vapors or gases. Specific precautions include:

- Confirm adequate hood performance before use. Hood should have annual performance certification. If certification is expired, do not use hood and contact TEHS.
- Many hoods have an airflow monitoring meter with rechargeable battery back-up. Do not unplug it! A quick, simple test of airflow is made by taping a piece of tissue paper to the bottom of the sash and observing its motion.
- Do not lift the sash above the 100-feet/minute mark, as indicated by a red dot or line on the side of the hood. If not working in the fume hood, the sash should be kept at 12" to allow airflow. While working in the hood, keep the sash as low as possible, but do not exceed a maximum sash height of 18 inches.
- Do not put your head inside a fume hood when conducting an experiment, even for a moment.
- Avoid storing equipment in a fume hood as it causes turbulence, resulting in leakage of airborne chemicals back into the laboratory. If equipment must be stored in a fume hood, elevate large equipment 1inch.
- Do not store chemicals in a fume hood. Move chemicals in and out as they are used.
- Work at 6-10inches inside the sash opening to capture airborne contaminants.

**2.4.4 Cryogenic Liquids –** The primary hazards of cryogenic liquids are fire or explosion, pressure build-up, embrittlement of structural materials, cold burn of skin and other tissue, and asphyxiation.

Because oxygen (-183°C) has a higher boiling point than nitrogen (-195°C), helium (-269°C), or hydrogen (-252°C), oxygen can be condensed out of the atmosphere during the use of these lower-boiling cryogenic liquids. Oxygen-saturated wood and asphalt have been known to explode when subjected to shock.

Very brief skin contact with a cryogenic liquid can cause tissue damage similar to a thermal burn. Prolonged contact may result in blood clots and corneal burns of the eyes. Cold gases can injure the nasal and breathing passage mucous membranes by freezing them.

Always wear adequate protective clothing, eye and face protection and heat resistant gloves when dealing with cryogenic liquids.

Full-face shields that protect the face and throat should always be worn while dispensing these liquids to protect against splattering. For maximum protection, goggles should be worn under the face shield.

Wear insulated gloves that are impervious to fluids and that are loose enough to be tossed off in the event of a spill. DO NOT TRAP COLD LIQUID INSIDE GLOVE.

Jewelry, especially finger rings, must not be worn since cold metal will increase the severity of damage done to the skin upon contact. Rings contract when cooled, and metals conduct heat away from skin.

Specific precautions:

- Store liquid nitrogen, dry ice and any other liquefied gases in well-ventilated areas to prevent displacement of oxygen and risk of suffocation.
- Do not store in walk-in cold rooms, as these are not ventilated.
- The sublimation of dry ice, for example, reduces the percentage of available oxygen, posing a suffocation threat to those who enter.
- Seal sample tubes tightly before storing in liquid nitrogen. Improper sealing of tubes can cause a pressure explosion upon removal from liquid nitrogen temperatures.
- Pressure vessels used for the storage and handling of liquefied gases should not be filled to more than 80% of capacity. This is a precaution against possible thermal expansion of the contents and bursting of the vessel by hydrostatic pressure. If the possibility exists that the temperature of the full cylinder might be increased to above 30ºC, to store cryogenic liquids, storage containers should only be filled to 60% of capacity. Glass thermos bottles must never be used!

**2.4.5 Distillation Procedures -** Distillation is a common procedure for purifying and separating chemicals. Specific precautions include:

- Assemble distillation apparatus inside a chemical fume hood. Do not fill distilling flasks more than two thirds. Always use boiling stone of Carborundum or other porous mineral or an ebullator to prevent the liquid in a boiling flask from superheating and becoming too turbulent. Always clamp a boiling flask onto a ring stand and support with a wire gauze platform. Carefully fit and clamp apparatus sections so that joints fit together snugly without tension. Lightly grease all joints to ensure a tight fit. Check for a clear vent opening before and throughout distillation to prevent pressure buildup and possible explosion. They must be free of peroxides before use as peroxides can cause explosions.
- Do not use Bunsen burners and hot plates for flammable liquid distillations. Only electric heating mantles or hot water and steam baths are permissible. Leave on the coolant in the condenser throughout the distillation procedure.
- Always stop distillations before the flask becomes completely dry. Without the absorption of heat due to vaporization, the flask temperature can rise rapidly. This is very important for ethers and other peroxide-forming chemicals.
- Use the following distillation shutdown procedure: shut off heat source; turn off coolant after system has cooled down and all vapors have condensed. Employ additional safeguards for unattended or overnight distillations.

Note: In addition to the above procedures, when performing vacuum distillation, be sure to:

- Reduce system pressure with an aspirator or pump before heating is begun.
- Maintain steady boiling by allowing a slow stream of inert gas such as nitrogen to flow into the liquid.
- Do not use cracked, scored, or badly scratched glassware that implodes easily.
- Only use glassware rated for vacuum use. Set up a protective, shatterproof shield in front of the experiment.

- Shield or wrap Dewar flasks and other evacuated glass apparatus to contain chemicals and fragments should an implosion occur.
- Use the following shutdown procedure: shut off heat source; turn off coolant after system has cooled down and all vapors have condensed; relieve vacuum slowly. Sudden pressure changes cause breakage and spillage.

**2.4.6 Electricity and Electrical Equipment -** Electricity and Electrical Equipment create shock and fire hazards if not installed operated and maintained correctly. This includes:

- All electrical equipment should be on grounded circuits, or itself be grounded.
- Portable space heaters should not be used in a laboratory, equipment room, or any chemical storage area.
- Electrical cords should not be damaged or worn. (Note: electrical tape on power cords does not constitute an acceptable repair.)
- Electrical cords should not be in pathways, under rugs or draped over light fixtures.
- Never operate equipment with the protective guards or covers removed.
- Use only U.L. approved three prong extension cords.
- Cords should not be longer than nine feet and cannot take the place of permanent wiring or outlets.
- Power strips should not be connected to other power strips. (Note: power strips should be connected directly to a wall outlet.)
- Bond and ground containers, lines and equipment used with flammable gases or liquids.
- Make sure before purchasing any new equipment that it can be used in your area without additional power or specific type of socket.
- Make sure that the volt, amp, watt ratings are marked on nameplates when equipment, new or used, is received from any source.
- The use of adapters two to three wire is not permitted.
- Facility Services staff can survey the load requirement on individual circuits and distribute them so that they are not overloaded.
- Do not allow anyone to paint over, obliterate or remove the nameplates on any equipment.
- Electrical panels and emergency shut off switches should not be obstructed. (Note: a 3-ft wide by 30” wide (or max width of panel if greater) of clearance is required)
- Mark your equipment clearly so incorrect connections will not be made if there are different voltages available in your work area.
- Employees must be trained to operate equipment, including using safety features and emergency shut-down.
- Inspect electrical equipment for unsafe conditions frequently, and in some cases, before each use. Look for loose connections or broken parts. Replace power cords and plugs when they show signs of wear or are broken. Protect all wires in or near traffic areas. Inspect open equipment, such as motors and relays, for dust and grease accumulation. Ensure that access to all electrical and fire alarm panels are unobstructed at all times. Clearly mark fuse and circuit breaker boxes as to what areas and equipment are covered by each. Check to see that signs are posted in areas where high voltage equipment is in use and posted on the doors leading into rooms with high voltage equipment.
- Do not modify or repair. Refer all repairs and cleaning to authorized technicians/service companies as indicated by the equipment owner’s manual.

**2.4.7 Emergency Eyewash and Safety Shower -** All personnel should be familiar with the use and locations of the nearest safety shower and eye wash station.

- PI/Supervisor will instruct employees on the location and use of eye wash stations and safety showers.
- Showers and eyewashes should not be more than 55 feet or 10 seconds away from the work area. Flush eyewashes once a week to confirm proper operation and to clean the system of old stagnant water.
- Shower and eyewash locations shall be marked with a highly visible sign. No items shall be stored underneath or in any way block access to a shower or eyewash.
- Do not tamper with or shut off the manual valve leading to the showerhead.
- Report any valve problems to Facilities Services. The pull chain or rod and attached ring used to activate the shower must be located at a height easily reached by all personnel. Access to the ring or activation device may not be blocked by equipment or materials in storage.
- Use the shower primarily to rinse an individual who has been splashed with chemicals. Use the eyewash to rinse eyes or face splashed with chemicals. The shower may be used secondarily to put out clothing fires only if the shower is in close proximity. Running any distance to a shower, fans the flame and intensifies the fire. Smother a clothing fire by dropping to the floor and rolling.
- Flush the skin or eyes for at least 15 minutes.
- Tufts Facility services tests eye wash stations and safety showers semi-annually. They note the date of inspection on the safety shower or eye wash tag.

**2.4.8 Emergency Response –** Dial 911 if there is an unplanned fire on the Boston Campus. All other emergencies should go through the Tufts Police to initiate appropriate action. Medical, fire, criminal, and chemical spills are examples of incidents that must be reported to the University Police at the following number.

**Fire on the Boston and SMFA campuses**
**9 1 1**

**Tufts Police Emergency Number:**
x66911 (on campus) or 617-627-6911

**Tufts Police Business Numbers:** Boston 617-636-6610 or x66610 Boston SMFA 617-627-3030 Medford/Somerville 617-627-3030 Grafton 508- 887-4900 or x84900

Every laboratory is equipped with a chemical spill kit. With a minor chemical spill, the primary concern is the protection of personnel. The secondary concern is to confine the contamination. Do not attempt to clean up a chemical spill if you feel incapable of doing so. Call your supervisor or a colleague for assistance. If the spill is of such magnitude that it is beyond the capabilities of laboratory personnel to clean up, call Tufts Police and ask them to contact TEHS. TEHS will call in an outside contractor to clean the spill.

Each lab should have the PIs off-hour emergency contact information listed with TUPD. Additional lab people can be listed at the discretion of the PI.
More information on accident and incident reporting can be found at:
https://publicsafety.tufts.edu/ehs/accident-and-incident-reporting-at-tufts-university/

**2.4.9 Needles, Syringes and Sharps -** Needles, Syringes and Sharps pose physical cut and puncture hazards as well as chemical and biological exposure hazards from contaminated needles. The following precautions should be noted:

- Needles, syringes and sharps must never be left in the open. Be sure to discard promptly after use in a sharps container.
- Do not recap needles, unless mandated by experimental procedures.
- Sharps containers are located close to point of use and should be replaced prior to the container being completely full.

**2.4.10 Refrigerator and Cooling Equipment -** Refrigerator and Cooling Equipment should be appropriate for the intended use. Specific precautions include:

- Never use ordinary household refrigerators for the storage of flammable or corrosive chemicals. Store flammable liquids in an approved flammable material storage refrigerator. These units have spark-free, explosion-proof interiors. Prominently label each refrigerator, freezer or cooler to indicate whether it is or is not suitable for storing flammable liquids.
- Never store foodstuffs in refrigerator or freezers which also contain chemical, biological or radioactive materials.
- Prominently display appropriate hazard sign and warnings for devices storing chemicals, biologicals and radioactive material
- Seal all containers to avoid evaporation and spills. Caps constructed of aluminum foil, corks, corks wrapped with foil, and glass stoppers are not adequate.

**2.4.11 Environmental Chambers and Walk-In Refrigerators, Freezers and Incubators -** These areas have limited ventilation and recirculated air.
Specific precautions include:

- Hazardous airborne contaminants should not be generated in these areas.
- Do not store cryogenic liquids or dry ice in walk-in cold rooms or environmental chambers because there is no ventilation and a suffocation hazard can be created.
- Hazardous materials should not be routinely stored or used in such chambers.
- Do not carry out experiments in these units
- Leave the door open while in the chamber and be aware of escape procedures

**2.4.12 Centrifuges-** Centrifuges are extremely common at Tufts University, however they present various hazards if misused or not maintained. Specific precautions include:

- Detailed records of operation must be kept for ultracentrifuges and rotors.
- Do not exceed the maximum speed rating for the rotor.
- Carefully inspect the condition of centrifuge tubes and rotors prior to ultra-centrifugation. Use appropriate tubes.
- If hazardous materials are being centrifuged in glass tubes, place the tubes in larger plastic tubes in case of breakage. Stop centrifuge immediately if an unusual sound or vibration begins. The lid must be closed during the entire operation.
- Materials spun in a centrifuge can develop aerosols. It is important to open any vials inside a biosafety cabinet or fume hood following spinning.

**2.4.13 Storing Chemicals in the Laboratory**

- Carefully read the label and the SDS before storing a chemical. Do not store chemicals in close proximity to each other. If they can react with each other to produce fire, explosion or toxic products, e.g., chlorine bleach and ammonia.
- Cabinets and shelving used for storing chemicals are in good condition and are appropriate for the weight.
- Chemicals should <u>not</u> be stored in alphabetical order. Storage of chemicals depends on chemical characteristics called hazard classes. Store chemicals that react similarly together. Acids and bases should <u>not</u> be stored together.

- Separate flammables that are compatible with water from those that are incompatible with water.
- Separate nonflammables that are compatible with water from those that are incompatible with water.
- Locate any materials that become unstable above room temperature away from heat. Store materials that become unstable at room temperature in an explosion-proof refrigerator, with an individual power source or alarm to warn of power failure and subsequent warming.
- Segregate pyrophoric materials, which will burst into flame when their container is broken, from flammables and other heat sensitive chemicals, and keep under considerable secondary containment, preferably under dry inert atmosphere.
- Isolate compressed gas cylinders from sparks or heat and
- Keep oxidizers separated from flammables.

Additional consideration must be paid to toxics, peroxides, oxidants, poisons, fuming corrosives, etc. to see where they fit into the basic flammability/reactivity categories. Chemicals that belong in the same storage area but are incompatible with each other, such as acids and bases, should be separated as much as possible.

- Once separated into hazard classes, chemicals may be stored alphabetically.
- Keep all containers well sealed to avoid vaporization and spills. Caps constructed of plastic wrap aluminum foil, corks, or glass stoppers are not adequate.
- Store flammable chemicals in approved flammable storage cabinets. Flammable storage cabinet should be designed and constructed per OSHA and NFPA requirements and contain the words "Flammable Keep Fire Away." Use FM or UL approved storage containers and safety cans for flammable liquids. No container of a flammable liquid may exceed a capacity of 2 gallons.
- Use spill trays under containers of strong reagents.
- Store corrosives in non-metallic or stainless-steel safety cans on lowest shelves.
- Store containers of inorganic hydroxides and hydrofluoric acid in polyethylene containers.
- Segregate acids from bases and active metals such as sodium, potassium, or magnesium. Segregate acids from chemicals which could generate toxic gases upon contact such as sodium cyanide, iron sulfide, etc. Segregate oxidizing acids from inorganic acids and flammable and combustible materials.
- Keep oxidizers, such as bromine, away from reducing agents such as zinc, formic acid, and alkali and alkaline earth metals.
- Containers with chemicals that present a risk for injury (i.e. corrosives) are stored in cabinets and shelves that are below eye-level.
- All shelves should have a protective edge guard to prevent containers from sliding off shelves.
- Do not store containers, full or empty, in walkways.
- Store acids where corrosive vapors cannot cause damage to wiring and piping. Store chemicals, particularly acids and water-reactives, in areas protected from water leaks and flooding, e.g., no storage under sinks.

- Always store chemicals of high acute and moderate or high chronic toxicity in unbreakable secondary containers.
- Nitric acid is incompatible with almost all other chemicals. It should be stored in a tub or basin in a storage cabinet.

**Incompatible Chemicals**
The following is a table containing examples of incompatible chemicals:

| Chemical | Keep Out of Contact With: |
|---|---|
| acetic acid | chromic acid, nitric acid, hydroxide compounds, perchloric acid peroxides, permanganates |
| acetylene | chlorine, bromine, copper, fluorine, silver, mercury |
| alkali metals | water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens |
| ammonia, anhydrous | mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid |
| ammonium nitrate | acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials |
| aniline | nitric acid, hydrogen peroxide bromine, same as chlorine |
| carbon, activated | calcium hypochlorite, all oxidizing agents |
| chlorates | ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials |
| chromic acid | acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general |
| chlorine | ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals |
| chlorine dioxide | ammonia, methane, phosphine, hydrogen sulfide copper acetylene, hydrogen peroxide |
| cumene hydroperoxide | acids, organic or inorganic |
| flammable liquids | ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens |
| hydrocarbons | fluorine, chlorine, bromine, chromic acid, sodium peroxide hydrocyanic acid, nitric acid, alkali |
| hydrofluoric acid | ammonia, aqueous or anhydrous |
| hydrogen peroxide | copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases |
| hydrogen sulfide | fuming nitric acid, oxidizing gases |

| | |
|---|---|
| iodine | acetylene, ammonia (aqueous or anhydrous), hydrogen |
| Mercury | acetylene, ammonia |
| nitric acid | acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases |
| oxalic acid | silver, mercury |
| perchloric acid | acetic anhydride, bismuth and its alloys, alcohols, paper, wood |
| potassium | carbon tetrachloride, carbon dioxide, water |
| potassium chlorate | sulfuric and other acids |
| potassium permanganate | glycerin, ethylene glycol, benzaldehyde, sulfuric acid |
| silver | acetylene, oxalic acid, tartaric acid, ammonium |
| sodium peroxide | ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural |
| sulfuric acid | potassium chlorate, potassium perchlorate, potassium permanganate (or similar light metals, such as sodium, lithium, etc.). |

## 2.5 Chemicals That Require Special Handling

**2.5.1 Compressed Gases -** There are multiple hazards associated with using and handling compressed gas cylinders. In addition, to the chemical hazard (i.e. what is in the cylinder), we must consider the physical hazards that are present if the cylinder were to rupture or break. The following is a list of general procedures:

- Always wear safety glasses when handling compressed gases.
- Always use the minimum size cylinder required to perform the work.
- Cylinders of compressed gases must be handled as high-energy sources.
- Do not expose cylinders to extreme temperatures.
- When storing or moving a cylinder, have the cap securely in place to protect the valve stern. (A pressurized cylinder can become a rocket when its valve is broken.)
- Use suitable racks, straps, chains or stands to firmly secure cylinders in an upright position.
- Use an appropriate cart to move cylinders.
- Always use the correct regulator. Regulator adaptors should not be used.
- Toxic, flammable or reactive cylinders should be stored and used in a fume hood or with local ventilation.
- Never bleed a cylinder completely empty. Always leave slight pressure to keep contaminants out.
- Oil or grease on the high-pressure side of an oxygen cylinder can cause an explosion. Do not lubricate an oxygen regulator or use a fuel gas regulator on an oxygen cylinder.

For additional information, refer to Compressed Gas Checklist at
http://publicsafety.tufts.edu/EHS/files/SafetyRequirementsforCompressedGasCylinders.pdf

**2.5.2 Peroxide Forming Chemicals -** Stability refers to the susceptibility of the chemical to dangerous decomposition. Ethers, liquid paraffins, and olefins form peroxides on exposure to air and light. Since these chemicals are packaged in an air atmosphere, peroxides can form even though the containers have not been opened. A number of deaths from explosions have occurred when researchers have attempted to open containers of old, outdated peroxide-forming chemicals. In these cases, peroxide sensitive crystals formed around the cap, the friction generated by turning the cap caused the shock-sensitive crystals to react, acting as a primer, and ignited the contents of the container, resulting in an explosion. Organic peroxides and peroxide-forming chemicals are considered among the most hazardous substances handled in laboratories because they are very unstable, flammable, and extremely sensitive to friction, impact, and heat.

The following is a list of general procedures:

- The label and SDS will indicate if a chemical is unstable. Purchase only what will be used in a short time and in the smallest size of container that is practical.
- Date containers upon receiving and again upon opening.
- Unless an inhibitor was added by the manufacturer, closed containers of ethers should be discarded after one (1) year or the manufacturer's expiration date (whichever comes first). Open containers of ethers should be discarded within six (6) months of opening. Do not open out-of-date containers, particularly if various liquids or crystalline solids are observed in liquid peroxide-forming chemicals. Write the date received on the container. Write the date container is opened on the label.
- Store flammable chemicals in a properly grounded flammable storage cabinet located in a cool dry place away from direct sunlight. Purchase peroxide forming chemicals in metal containers. Although less preferable, amber bottles are also acceptable. Cap containers tightly to minimize peroxide formation. Keep bottles and caps free of chemical residue. Do not store ether in refrigerators, unless they are an approved explosion-proof refrigerator. Chill ether in ice bath if chilling is required.
- Handle peroxide-forming compounds in a laboratory hood. The immediate area must be free of ignition sources such as Bunsen burners and electrical equipment. Wear protective eyewear, gloves and laboratory coat when handling shock sensitive compounds.
- Never distill ethers unless they are known to be free of peroxides. Do not distill to dryness. Leave at least 10 percent at the bottom as most accidents involve a nearly dry residue.
- Carefully handle near-empty and empty containers as an air space above the liquid accelerates the formation of peroxides.
- Be careful with potassium and sodium They are water reactive metals, usually stored in kerosene or preferably mineral oil. A potential exists for them to react with moisture in the air.

**Maximum Storage Time Periods for Peroxide-Forming Compounds**

**Three Months:**

| | |
|---|---|
| Divinyl acetylene | Sodium amide |
| Isopropyl ether | Potassium metal |
| Vinylidene chloride | |

**Twelve Months:**

| | |
|---|---|
| Acetal | 2-Hexanol |
| Acetaldehyde | Methyl Acetylene |
| Benzyl Alcohol | 3-Methyl-1-butanol |
| 2-Butanol Dioxanes | Methyl-isobutylketone |
| Butadiene | 3-Methy-2-pentanol |
| Chlorofluoroethylene | 2-Pentanol |
| Chlorobutadiene (Chloroprene) | 4-Penten-1-ol |
| Chlorotrifluoroethylene | 1-Phenylethanol |
| Cumene (isopropylbenzene) | sec. Alcohols |
| Cyclohexene | Styrene |
| 2-Cyclohexen-1-ol | Tetrafluoroethylene |
| Cyclopentene | Tetrahydrofuran |
| Decahydronapthalene (decalin) | Tetrahydronnapthalene |
| Diacetylene (butadiyne) | Vinyl acetate |
| Dicyclopentadiene | Vinyl acetylene |
| Diethyl ether | Vinyl chloride |
| Diglyme | Vinyl ether |
| Dioxane | Vinyl ethyl ether |
| Ethylene glycol dimethyl ether | Vinyl isobutyl ether |
| Furan | Vinyl methyl ether |
| 4-Heptanol | Vinyl pyridine |

**2.5.3 Shock-Sensitive Chemicals -** Shock sensitive refers to the susceptibility of the chemical to rapidly decompose or explode when struck, vibrated or otherwise agitated. The following is a list of general procedures:

- Some chemicals become increasingly shock-sensitive with age. Date containers upon receiving and again upon opening of shock-sensitive chemicals.
- Unless an inhibitor was added by the manufacturer, closed containers of shock- sensitive materials should be discarded after one (1) year.
- Open containers of shock-sensitive material should be discarded within six (6) months of opening.
- The label and SDS will indicate if a chemical is shock-sensitive.
- Wear appropriate personal protective equipment when handling shock-sensitive chemicals.
- Many of these chemicals such as picric acid, dinitrophenylhydrazine must be kept wet.

**2.5.4 Organic Solvents -** Many of the commonly used solvents are volatile and are harmful when relatively small amounts are inhaled. Most are readily absorbed through the skin. Most are

flammable. Flammable liquids are more hazardous at elevated temperatures due to more rapid vaporization. The following is a list of general procedures:

- Electrically ground and bond containers using approved methods before transferring or dispensing a flammable liquid from a large container.
- Purchase only the amount necessary for immediate use.
- Use approved flammable liquid containers and storage cabinets.
- Keep flammable liquids from heat, flame, and direct sunlight.
- Do not store flammable liquids near oxidizing agents such as chromic acid, permanganates, and chlorates.
- Avoid skin contact and inhalation of solvents.
- Use assigned personal protective equipment.
- Do not dispose of solvents down sinks or drains.
- Use with adequate ventilation or in fume hood.

**2.5.5 Working with Chemicals of Moderate Chronic Toxicity -** These procedures should be followed when using substances for which infrequent, small quantities do not constitute a significant hazard or carcinogen hazard, but which can be dangerous to those exposed to high concentrations or repeated small doses. A substance that is not known to cause cancer in humans, but shows statistically significant, low, carcinogenic potency in animals should be handled in this manner as well. The particular rules listed below supplement those followed in any chemical handling procedures and are to be followed.

- Aim to minimize exposure to these toxic substances by any route, using all reasonable precautions.
- Use and store these substances only in areas or restricted access with special warning signs.
- Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 100 linear feet per minute) or other containment device (the hood or other containment device must vent to outside air) for procedures that may result in the generation of aerosols or vapors containing the substance.
- Always avoid skin contact by use of gloves or long, gauntlet-type gloves and long-sleeved laboratory coat (and other apparel as appropriate). Always wash hands and arms immediately after working with these materials. Thoroughly decontaminate all working surfaces.
- Maintain records of amounts of these materials on hand, amounts used, and the names of the workers involved.
- Be prepared for accidents and spills. Store in unbreakable primary or secondary containers in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper.
- Discard contaminated clothing or shoes. Store waste and contaminated materials in closed, suitably labeled impervious containers. Review waste management guidelines or contact TEHS at x63615.

**2.5.6 Working with Highly Toxic and/or Reactive Chemicals (High Hazard Chemicals) -** These are additional practices to be followed, in addition to all those listed for working with substances of moderate chronic toxicity (in the previous section) for work with; reactive chemicals, substances of known high toxicity (defined below), select carcinogens, reproductive hazards, or neurotoxins. These are requirements to follow when working with quantities above a few milligrams to a few grams, depending on the substance.

A reactive chemical is one that is self-reactive, shock sensitive, pyrophoric or water reactive.

Self-reactive chemicals are thermally unstable liquid or solid chemicals liable to undergo a strongly exothermic decomposition even without participation of oxygen (air). Pyrophorics, even in small quantities, are liable to ignite within five minutes after coming into contact with air. Water reactive chemicals are chemicals which, in contact with water, emit flammable gases are solid or liquid chemicals which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.

A substance is a considered highly toxic if it is known to be highly acutely toxic in humans or in comparable animal models as follows:

- Chemicals with an oral median lethal dose (LD50 oral-rat) of 50 mg/kg or less.
- Chemicals with a skin contact median lethal dose (LD50 skin-rabbit) of 200 mg/kg or less.
- Chemicals with inhalation toxicity (LC50-rat) of 200 ppm or 2 mg/L or less in 1 hour.

This procedure should be followed when working with reactive or highly toxic chemicals, select carcinogens, reproductive hazards (mutagens or teratogens), or neurotoxins:

- Conduct all transfers and work with these substances in a "controlled area" which includes a restricted access hood, glove box, or portion of a laboratory, designated for use of high hazard substances. The sash on the fume hood should be kept as low as possible while working with reactive chemicals. All people with access to controlled areas must be aware of the substances being used and must take necessary precautions.
- Confirm adequate hood performance before use; keep hood sash at the 100 feet per minute indicator at all times, except when moving equipment into and out of the hood; keep materials stored in hoods to a minimum and do not allow stored materials to block air flow.
- Some fume hoods have off-on switches. Leave the hood "ON" in the following circumstances: if toxic substances are stored in it; or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "OFF."
- Complete a High Hazard Chemical Registration Form and prepare a safety plan for use and disposal of these materials and obtain the approval of the laboratory supervisor and TEHS. The High Hazard Chemical Registration form can be found at: https://publicsafety.tufts.edu/ehs/chemical-hygiene/
- Decontaminate the controlled area before normal work is resumed there.
- On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled waste container) and thoroughly wash hands, forearms, face, and neck.
- Keep accurate records of the amounts of these substances stored and used, the dates of use and names of users.
- Assure that the controlled area is conspicuously marked with warning and restricted access signs and that all containers of these substances are appropriately labeled with identity and warning labels.
- Store containers of reactive chemicals and chemicals of high chronic toxicity only in a ventilated, limited access area in appropriately labeled, unbreakable, chemically resistant, secondary containers.
- Store containers of reactive chemicals and chemicals of high chronic toxicity only in a ventilated, limited access area in appropriately labeled, unbreakable, chemically resistant, secondary containers.
- If using toxicologically significant quantities of chemicals of high chronic toxicity on a regular basis (e.g., 3 times per week) or for long periods of time (4-6 hours), consult a qualified physician concerning desirability of regular medical surveillance.
- Flame resistant laboratory coats and additional appropriate PPE should be work when

working with reactive chemicals.

**2.5.7 Toxicology Overview**

**Toxicology** is the study of the nature and action of poisons; the adverse health effects of chemical materials.

**Toxicity** is the ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or on the body. Descriptions of toxicity (e.g. low, moderate, severe, etc.) depend on dose needed to cause an effect or the severity of that effect.

**Dose-Response Relationships: "The Dose Makes the Poison"**

A chemical normally thought of as "harmless" may produce a toxic response if added to a biological system in a sufficient amount or dose. The potency of a chemical is thus ultimately defined by the relationship between the dose (the amount) of the chemical and the response that is produced in a biological system.

**Routes of Entry into the Body**

The main routes by which hazardous chemicals enter the body:

- **Absorption through the respiratory tract via inhalation.**
- **Absorption through the skin.**
- **Absorption through the digestive tract.**
- **Accidental injection.**

Most exposure standards, Threshold Limit Values (TLVs) and Permissible Exposure Limits (PELs), are based on the exposure by inhalation. Concentrations in air are typically expressed in terms of parts per million (ppm) or milligrams per cubic meter ($mg/m^3$) concentration in air.

**Types of Effects**

**Acute poisoning** is characterized by rapid absorption of the substance and the exposure is sudden and severe. Normally, a single large exposure is involved. Examples: carbon monoxide or cyanide poisoning.

**Chronic poisoning** is characterized by prolonged or repeated low level exposures of a duration measured in days, months or years. Signs and symptoms may not be immediately apparent. Examples: lead, mercury, asbestos, silica.

**Local** refers to the site of action of an agent and means the action takes place at the point or **area of contact. The site may be skin, mucous membranes, the respiratory tract, gastrointestinal system, eyes, etc.** Absorption does not necessarily occur. Examples: strong acids or alkalis and chemical warfare gases.

**Systemic** refers to a site of action other than the point of contact and presupposes absorption has taken place. For example, an inhaled material may act on the liver. Other examples: arsenic affects the blood, nervous system, liver, kidneys and skin; benzene affects bone marrow.

**Cumulative poisons** are characterized by materials that tend to build up in the body as a result of numerous chronic exposures. The effects are not seen until a critical body burden is reached. Example: heavy metals.

**Substance in Combination**: When two or more hazardous materials are present at the same time, the resulting effect can be greater than the effect predicted based on the individual

substances. This is called a synergistic or potentiating effect. Example: exposure to alcohol and chlorinated solvents.

**Other Factors Affecting Toxicity**

**Rate of entry and route of exposure**; that is, how fast the toxic dose is delivered and by what means.

**Age** can affect the capacity to repair tissue damage. **Previous exposure** can lead to tolerance, increased sensitivity or make no difference. **Host factors**, including genetic predisposition and the gender of the exposed individual. **State of health,** physical condition and life style can affect the toxic response. Preexisting disease can result in increased sensitivity.

**Environmental factors** such as temperature, humidity and atmospheric pressure.

## 2.6 Waste Management

Tufts University is responsible for the proper management and disposal of all chemical waste that it generates. With the assistance of TEHS each individual generator (i.e. laboratory, shop, etc.) is responsible for maintaining compliance with Federal, State and Local regulations.

A chemical waste is any chemical that exhibits one of the following characteristics and should be disposed of:

- Shelf-life expiration dates have been exceeded.
- Chemicals are stored in old, bulging, badly decomposed or damaged containers.
- Chemicals have become obsolete because of questionable purity or discontinued usage.
- Chemicals have undergone visible changes (i.e. amber-colored perchloric acid).
- Chemicals with illegible or no label are considered unknowns and should be disposed of.

Once it has been determined that a chemical needs disposal, personnel must determine whether it is a HAZARDOUS waste. A Hazardous waste is a waste listed by the Environmental Protection Agency (EPA) or a waste that exhibits one of the following characteristics; Ignitable, Corrosive, Reactive, or Toxic. If it meets any of these criteria it must be managed and disposed per Resource Conservation and Recovery Act (RCRA), Department of Transportation (DOT) for hazard class and University Policy guidelines.

Please see Tufts Hazardous Chemical Waste Management Plan for more information: http://publicsafety.tufts.edu/ehs/environmental-management/hazardous-chemical-waste-management/

**Waste Pick-Up -** For assistance with pick-ups contact TEHS at x63615 or place an online request on the TEHS webpage. Be sure to have the following information available:

- Name/ Make-Up of Waste
- Quantity
- Building & Room Number
- Principal Investigator/Contact Name & Extension

## 3. Administrative Practices/Controls:

**Administrative controls** (or work practice **controls**) are changes in work procedures such as written safety plans, policies, rules, supervision, schedules, housekeeping, personal hygiene, and appropriate work practices and training, The goal of administrative controls is to reduce the duration, frequency, and severity of exposure to hazardous chemicals or situations.

Some administrative controls can be found on the TESH website at:
https://publicsafety.tufts.edu/ehs/tufts-university-experiment-hazard-assessment-tool/
https://publicsafety.tufts.edu/ehs/a-z-guide/
https://publicsafety.tufts.edu/ehs/chemical-sop/

## 3.1 Prior Approvals; Safety Plans for High Hazard Chemicals

High hazard chemicals are either highly toxic or reactive chemicals (see section 2.5.6 and 2.5.7). These require a chemical registration and a safety plan.

### 3.1.1 In Vitro High Hazard Chemical Use

Prior to new chemicals being introduced to a laboratory, the PI and/or Supervisor is responsible for evaluating potential hazards and control measures needed to mitigate these hazards.

If the chemical is determined to be a high hazard the PI must submit a chemical registration form to TEHS.

The Safety Plan for this chemical will consist of; the approved chemical registration form, the SDS sheet and any additional stipulations in the TEHS approval letter or email, any SOPs.

TEHS has developed a number of Standard Operating Procedures (SOPs) for commonly used high hazard laboratory chemicals.

Laboratories may choose to write their own SOP for high hazard chemicals which will become a part of the safety plan.

#### 3.1.1.1 Creating Laboratory Specific Standard Operating Procedures (SOPs)/Safety Practices

Supervisors should provide laboratory staff with Standard Operating Procedures (SOPs) that identify safe practices to follow for all laboratory work involving hazardous chemicals. A laboratory SOP is a detailed procedure that contains enough specific information for the reader to safely perform the experiment. Introduction of any new chemicals or procedures will require review and possible revision of existing SOP or development of a new SOP.

Standard operating procedures should be developed with the idea of (1) preventing exposures to a hazardous chemical by detailing the methods and equipment that should be used and (2) give clear instruction on how to handle an emergency spill or exposure to the reagent.

### 3.1.2 In Vivo High Hazard Chemical Use

Any research on animals must be approved by the Institutional Animal Care and Use Committee (IACUC). PIs must complete and submit the animal care and use protocol forms to the IACUC for prior approval. Any drug or chemical administered to the animal is reported on this form. TEHS reviews these protocol forms for high hazard chemicals.

High hazard chemicals used with animals requires PIs to submit a High Hazard Chemical Registration Form to the TEHS for approval. At minimum this will include amount of chemical, practices by which it will be administered, personal protective equipment, and waste disposal.

The safety plan will consist of; the approved High Hazard Chemical Registration Form, the chemical's SDS sheet, a TEHS approval letter and the Animal Care Facility's Safety Plan for

that particular chemical.

## 3.2 Medical Consultation and Evaluation

The University shall provide all employees who work with hazardous chemicals in laboratories an opportunity to receive medical attention, including any follow-up examinations, which the examining physician determines to be necessary, under the circumstances listed in this section. Such medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

- If an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
- Where exposure monitoring reveals an exposure level routinely above the action level (or in absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
- If an event takes place in the work area such as a spill, leak, explosion, or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.
- Supervisors must file within 5 days an Employer's First Report of Injury Form with the Department of Risk Management and Insurance for all employees that report injuries or seek any medical consultation, treatment or examination under this section.

## 3.3 Airborne Chemical Exposure Assessment and Monitoring

Routine monitoring of airborne concentrations of chemicals in laboratories is not usually justified or practical. Monitoring may be required when a highly toxic substance is stored or used routinely (e.g, 3 times/week) and a potential hazard exists with one or more chemicals. If a laboratory meets the testing criteria or the laboratory supervisor has reason to believe that laboratory air is chemically contaminated, contact the Tufts EHS to initiate employee or workplace air monitoring.

Respiratory protection devices should not be needed in a laboratory if laboratory ventilation and fume hoods are maintained and used correctly.

For more on Tufts Respiratory Protection Program see:
http://publicsafety.tufts.edu/ehs/ppe/respiratory-protection-program/
If respirators are required, a qualitative fit test will be performed by TEHS and the respirator will be provided to the employee at no cost.

## 3.4 Laboratory Inspections

Routine Laboratory Inspections cover laboratory areas and primarily focus on NFPA, OSHA, EPA regulations and best management practices. The announced TEHS walk-through is typically done by one member of the TEHS staff and at least one laboratory staff member. Results are recorded on the Laboratory Inspection Form and distributed to the appropriate PI/Supervisor.

Additional informal inspections should be periodically conducted by the PI/Supervisor.