LABORATORY SAFETY MANUAL

Clinical Lab Sciences department

College of Applied Medical Sciences

King Saud University

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Abbreviations'

CAMS- College of Applied Medical Sciences

CFATS- Chemical Facility Anti-Terrorism Standards

CHP- Chemical Hygiene Plan

CLS- Clinical Laboratory Sciences

FMEA- Failure mode and effective analysis

Hazop- Hazard and operability study

HEL- Higher explosive limit

KSU- King Saud University

LEL- Lower explosive limit

LFL- Lower flammability limit

LI- Lab In charge

LSM- Laboratory Safety Manual

NFPA- National Fire Protection Association

PEL- Permissible exposure limits

PPE- Personal protective equipment

RP- Responsible Party

SDS- Safety data sheets

SOPs- Standard operating procedures

UFL- Upper flammability limit

SECTION 1: LABORATORY RESPONSIBILITIES

A. PURPOSE

Clinical Laboratory Sciences (CLS) in College of Applied Medical Sciences (CAMS) at King Saud University (KSU) has committed to creating, maintaining and enhancing a safe and healthy environment for all institution-related individuals, including students, faculty, and personnel.

1. Laboratory

A laboratory is defined as an area which might be single or group of room, or part of a room known as the laboratory of a particular researcher, where experiment is performed for educational, or clinical purposes. The manipulations may require combining various hazardous chemicals/microbial products/biological samples into a range of preparations, performed on a small scale, and a chemical laboratory must also have safety practices or safety equipment to minimize the hazardous chemicals threats.

The Chemical Hygiene Plan (CHP) describes laboratory practices, laboratory equipment, personal protective equipment (PPE) and procedures to help ensure that CLS department laboratory employees are protected from the hazards associated with the use of chemical substances. The CHP for CLS-lab can be computer, paper or combination. Laboratory staffs working in areas involving hazardous chemicals must be able to access it at all times. The CHP should be accessible for all the employees working in CLS department. Laboratory-specific information such as chemical inventories, standard operating procedures (SOPs), or safety data sheets (SDS) and other reference materials may be kept in the lab or elsewhere if necessary. Individuals may keep personal copies of the

Laboratory Safety Manual (LSM) and the lab's SOPs, but a master index of where the complete CHP is located, identifying the current revision number or date for each part, should be easily available to all personnel at all times Some information not directly associated with safety procedures, which might be troublesome to replace if lost, such as certifications that individuals completed safety training, may be kept separately in locked cabinets. That location should be identified in the laboratory- specific information section.

Laboratory Safety Manual contains information applicable to the CLS laboratories, explanatory materials and biological hazards to comply with regulations. Pertinent regulations covering laboratories include:

2. Chemical Waste Management

CLS Laboratory Safety Manual also includes information on chemical waste management in order to assist laboratories in complying with Kingdom of Saudi Arabia regulatory standard, Dangerous Waste Regulations

3. Chemical Hygiene Plan Accessibility

The CHP must always be accessible to laboratory employees and students at all times the laboratory is occupied. If multiple rooms are included in the laboratory, the plan must be available without

having to get a key from another person or leaving the lab space.

4. Applicability to Students

It is the policy of the CLS that students in laboratories are given the same level of protection as university employees while not technically bound by these procedures.

5. Chemical, Non-Chemical Hazards and Biological Hazards

Hazardous chemicals are considered to be those which either present or could cause a health hazard such as an acute skin burn from a corrosive acid or a

disease from a chronic, long-term exposure, or a physical hazard from a chemical action such as a fire or explosion. Hazardous chemicals can often be identified from their labels, which could state “Danger,” “Warning,” “Caution” or words to that effect, or the label could have a symbol which indicates a hazard. The chemical’s SDS may also indicate that the chemical has dangerous properties, could cause some disease or injury or that personal protective equipment, such as gloves, is recommended when handling the chemical. In addition to chemical hazards, this Laboratory Safety Manual provides information about general hazards (e.g., electrical safety, high noise, etc.) which may be present in the laboratory environment. Biological/infectious hazards include bacteria, viruses, insects, plants, poultry, animals and humans. These dangers may cause a variety of health issues, ranging from skin irritation and allergies to diseases (tuberculosis and AIDS), disease (liver cancer, and infection with hepatitis viruses of B and C), etc. Infection can be caused by various types of organisms including bacteria, viruses, fungi, parasites, and prions.

B. RESPONSIBILITIES

1. Responsible Lab in charge

Chemical laboratory must have a single Lab incharge (LI) which is an entity appointed by a department. The LI has scientific and technical advice in the laboratory space for the research or activities. The LI has the responsibility and authority to enforce regulations and policies relating to safety; this includes ensuring the services are appropriate for the research carried out. Based on state regulations, each laboratory must also have a responsible person who is informed about the procedures performed by the laboratory, is actively involved or monitors of those procedures, and has the authority to enforce correct procedures. The laboratory’s LI must ensure the following is accomplished:

2. Develop the CHP

Any laboratory must have a CHP consisting of the Laboratory Safety Manual plus information specific to the laboratory. The major areas of the laboratory-specific information portion include:

• The safety requirements, either as laboratory rules or SOPs which include PPE requirements

• Laboratory-specific topics covered in the laboratory's training program

• Additional details specific to the laboratory and generally described on the laboratory-specific information template in Appendix C of the Laboratory Safety Manual.

3. Create a List of Chemicals Stored in the Laboratory

An accurate list of chemicals which is available in the laboratory must be documented and entered into the precise rooms and updated annually, at minimum.

4. Identify and Assess Hazards

The LI must ensure that all laboratory staff understand the hazard assessment must be made with fresh and updated procedures. The LI or the laboratory person familiar with the procedures of the laboratory shall evaluate certain procedures and shall determine measures to effectively minimize risks. Any employee of the laboratory may recognize hazardous conditions which could result in personal injury or damage to property. Once identified, the hazardous conditions must be assessed. Steps in the assessment include:

1. Research chemicals and processes to be used

2. Identify and evaluate all types of hazards involved. Some evaluations to consider: what are the hazards? What is the worst that can happen? What can be done to prevent that? What can be done to minimize each risk? What should be done if something goes wrong?

3. Consider if additional hazards may be present, if scaling up

5. Ensure emergency response situations have been addressed:

If the assessment results in requirements for controls, the requirements must be documented. For best practices, it is recommended that the assessment be documented, whether or not controls are required.

6. Document and Enforce Appropriate Safety Practices

Safe laboratory work practices and guidelines that are needed must be recorded. Specifications can be conspicuously written in the laboratory or included in SOPs as "general laboratory regulations." If an individual fails to meet the requirements, the responsible party of the laboratory shall initiate enforcement actions and record such activities.

7. Ensure Signage/Labels in Place

Appropriate signage must be posted and hazardous material containers must be labelled.

8. Assess, Provide and Document Training

The responsible person of the laboratory shall ensure that the training requirements for staff are specified according to their duties. Employees, visiting scientists, and students working in the laboratory may receive general and laboratory-specific instruction, including the dangers of the present chemicals, and the necessary safety procedures including the use of PPE. The CLS department may provide general requirement information, such as emergency response procedures. Laboratory personnel are responsible for the planning standards pertaining to the products and procedures carried out within the laboratory; the analysis and examination must be reported.

9. Ensure Staff Have Access to Safety Information

All personnel who work in areas with hazardous chemicals must have access to essential safety information while they are at work, including the CHP, SDSs and the regulation. This information should be available in the laboratory space where work is performed.

10. Ensure Visitor Safety

1. Before starting any chemical use, visiting scientists and volunteers performing procedures within the laboratory must receive equivalent training as other employees on the hazards and safety precautions, including requirements for use of PPE.
2. Visitors must be shielded from the dangers within the facility, decontaminated and washed before they can touch those surfaces and equipment.

11. Enforce Restrictions on Children and Minors

The laboratory must not be used as a childcare area, in accordance with the CLS Administrative Policy Statement. Juveniles (age 14 - 17) working as volunteer workers or as staff in the facility must not be exposed to contaminants that face higher health risks. These risks involve items such as human body fluids, toxic and dangerous chemicals, or job that needs PPE other than goggles, footwear, eye protection or hard hats. Specific student-learner exemptions apply to juveniles (age 16 and 17) if the position or volunteer assignment is part of a technical education program, or if the minor is involved in a CLS college credit course.

12. Enforce Restrictions on Pets

CLS department forbids pets in laboratory premises.

13. Perform Annual Reviews and Update Documents

Annually, LI should ensure the new material has been incorporated into the CHP and evaluate that circumstances have not improved from a safety perspective by: reviewing (end of academic year, annually) for updates to the Laboratory Safety Manual; receiving a current copy of the LSM and making it available to all employees.

• Check that actual laboratory procedures and conditions remain consistent with SOPs and other laboratory-specific information

• Review internal inspection results and the condition of equipment used by laboratory staff to identify possible safety deficiencies, such as dirty, defective, or worn equipment; out-of-date fire extinguisher; emergency shower inspections; etc.

• It is recommended that laboratory staff make any changes necessary and note the annual review.

14. Perform Accident Follow-up

One must disclose all accidents and incidents. Any accidents/incidents that result in injury to staff to the degree that they require medical attention, and accidents/incidents involving unplanned fires and explosions, shall be reported to the LI. It is proposed that incidents which do not result in significant injury or damage but contribute to close misses also be recorded to the responsible person of the laboratory.

15. Department of Chair and Director

Departmental Chair is responsible for the following:

16. Ensure Safety of Laboratory Occupants

Provide a safe and healthy workplace free from recognized hazards. This can be accomplished by being aware of the CLS Accident Prevention Program, being familiar with Departmental health and safety plans and the activities generally being conducted, being aware of the general requirements in this manual and other safety and health requirements, and taking

a. reasonable approach in minimizing hazards and risks.

17. Enforce Laboratory Control Methods

Ensure the SOPs about the use of specifically hazardous substances define conditions for authorization

18. Review Accidents

Have procedures in place to become knowledgeable of incidents impacting laboratory operations within the CLS-labs, and ensure that corrective action is taken to prevent recurrence of injuries if appropriate.

19. Review and Follow Up on Inspection Findings

Ensure that corrective actions are completed for safety deficiencies.

20. Ensure Appropriate Laboratory Closures/Moves

Ensure laboratory closures or moves are done responsibly.

21. Assume responsible party (RP) duties or assure a RP is appointed for a laboratory when there is an extended absence of the LI. This may be due to sabbatical, extended remote work assignment, retirement, or illness.

22. Employees/Students

Employees and students have a responsibility to:

a. **Comply with Guidelines and Policies**

Know and comply with lab safety guidelines and policies required for all assigned tasks.

b. **Report Unsafe Conditions**

Report unsafe conditions to your LI or Chairperson of the CLS department. If you identify a procedure or assigned task as being exceptionally risky, you can perform it only after you believe the risk has been reduced to an acceptable level.

c. **Report Accidents**

Report accidents and incidents to your supervisor, and to the CLS department.

d. **Use Personal Protective Equipment**

Select, maintain and use PPE appropriately, consistent with your training. Students may be required to provide your own PPE for use in academic laboratories.

23. Environmental Health and Safety Department EH&S is responsible for the following:

Develop the Laboratory Safety Manual produce and update CLS Laboratory Safety Manual, which provides generic information for each laboratory.

24. Perform Laboratory Surveys/Audits

Conduct laboratory surveys and assist in implementation of self-inspection procedures.

25. Conduct General Lab Safety Training

Develop and provide general safety training courses in CLS laboratory safety, such as the instructor led Laboratory Safety Practices.

SECTION 2 - CHEMICAL MANAGEMENT

BASIC LABORATORY SAFETY PRACTICES

1. Working Alone

Do not work individually in the laboratory where highly toxic chemicals or processes are included in the procedures undertaken. If you deal with smaller threat chemicals on your own, let other laboratories know about your involvement or establish an accountability system for your boss or colleagues. Be aware of any specific laboratory policies pertaining to operating alone.

2. Prevent Hazardous Exposure

Prevent skin contact with chemicals: For example, use appropriate personal protective

equipment as per Lab Safety Manual, (e.g., goggles, gloves, and/or lab coat) but consider it as the last line of defense and use other precautions, such as appropriate containment equipment and checking regularly that connections are tight. Clean up spills as soon as possible and minimize clutter at workspaces to avoid inadvertent exposure. Prevent inhalation of chemicals

To avoid inhalation of a chemical:

• Use a fume hood whenever handling volatile or aerosolized chemicals, even if they are of relatively low toxicity.

• Cap chemicals as soon as possible.

• Limit the smelling of chemicals to the minimum amount necessary; only smell a chemical if no other method of identifying a chemical is available and just waft the air at the container opening towards your nose.

• Investigate the source of unfamiliar odors in order to eliminate them. Prevent ingestion of chemicals to avoid ingestion of a chemical:

• Do not taste any chemicals/any microbial media or biological samples.

• Mouth suction must never be used to pipet chemicals or start a siphon; instead, use a pipet bulb or an aspirator.

• The harmful effects of these biological hazards on human health are mostly of three types-infections, asthma and poisoning

• Avoid touching your mouth and face with your hands while working with chemicals. Prevent injection of chemicals to avoid injection of a chemical:

• Dispose of needles as soon as any injection is complete.

• Use needles with inherent safety devices that prevent inadvertent needle sticks.

• Dispose of sharps into appropriate waste containers and do not over-fill sharps containers.

• If operating a high-pressure system, never check for a pressure leak using your hands.

• Do not carry any kind of laboratory sharp in your clothing or lab coat pocket

3. Washing Hands

After removing gloves and leaving the laboratory area, wash hands well with soap and warm water. Never wash organic solvents with any.

4. Food and Drink

Laboratory food and drink intake increases the likelihood of exposure to chemicals; consumables are forbidden from being processed, cooked, or eaten in chemicals-using CLS laboratories.

5. Glassware/Utensils

Glassware or utensils used for laboratory operations must never be used to prepare or consume food or beverages.

6. Storage of Food/Beverages

Laboratory refrigerators, ice chests and cold rooms are not allowed for food or beverage storage intended for human consumption.

7. Access to Emergency Exits and Equipment

Emergency equipment, such as eyewashes, showers, fire extinguishers and fire alarm pull stations must be directly accessible. Storage, even temporary storage, and equipment must not block doorways, corridors, aisles and stairways to assure unobstructed access to exits in the event of an emergency.

8. Laboratory Signs

Laboratory Caution signs must be posted. These signs may provide information, prohibit unsafe behavior, require protective measures or designate locations of various supplies and equipment. Magnetic or framed Caution signs may be used to designate a temporary hazard. Warning signs must be removed when the hazard no longer exists.

9. Housekeeping

Laboratory bench tops and other work surfaces must provide enough space to safely execute procedures. Aisles and egress routes must be clear to allow for prompt evacuation in the event of a spill, fire or other emergency.

Maintain the following housekeeping expectations in the laboratory at all times:

- Flammable materials kept away from ignition sources
- Incompatible materials and chemicals must be separated
- Emergency equipment and supplies (eyewash, shower, spill kit, fire extinguisher) readily accessible
- Fume hoods uncluttered
- Orderly chemical storage
- Chemical labels complete, legible, and visible when stored
- Limited use of the floor for storage; avoid trip hazards
- Clean work surfaces
- Sinks kept clear
- Minimum amounts of garbage/trash

• Tubing and power cords protected from physical damage and not a tripping hazard

10. Sharps Safety

Sharps are devices which are used to cut or puncture parts of the skin or body including sticks, scalpels and lancets. Other sharp objects can still cause injuries although they do not fit the regulatory definition of sharps, such as broken glass, glass septum vials, glass pipets, razor blades, sharp teeth and research animal nails. Precautions to prevent injury and exposure are important. Identify sharps for use in laboratory procedures. Replace a non-sharp substitute such as a blunt needle or plastic pipette, or try using a secure sharps unit, if appropriate. Training and preparation are important to avoid injuries when a sharp one needs to be used. Stop recapping needles; use a needle holder to recap the needle if necessary. Never leave an unused needle hidden in the work area. Place all sharp waste in a red sharps container as quick as possible. Store reusable sharps such as a bucket or tray, in a labelled storage container. Use a magnet to hold reusable metal sharps, such as razor blades. Avoid factors and conditions that can lead to the injury of a sharp person, such as hurrying, or working when you are tired or feel bad. Keep the work area organized and uncrowded so sharp items are visible at all times.

11. CHEMICAL INVENTORY AND THE SAFETY DATA SHEET (SDS)

Laboratories must maintain chemical inventories in CLS-wide chemical tracking system. This is designed to track inventories during emergencies and assist laboratories in complying with federal, state and local regulations. Chemical inventories, location contacts and chemical-specific hazard summaries must be available to emergency personnel so they know what chemicals may be involved in an accident and whom to contact in the event of an emergency. Laboratories should use precise inventories to keep track of chemicals, avoid unnecessary

purchases, prevent keeping legacy or unneeded chemicals and submit chemical collection requests.

12. Conducting Your Chemical Inventory

Personnel must inventory all chemicals found in the laboratory and specify the maximum amount normally found at this location. Dilutions and reagents prepared in the lab for further work do not need to be included in the inventory, but must have a container label visible, unless the entire preparation is used or disposed of on the same day. Review and update inventories annually, when moving a laboratory or starting a new project or whenever there are significant changes in your chemical inventory.

13. Safety Data Sheet (SDS)

Safety Data Sheets (SDSs) are documents that describe the physical and health hazards of chemicals. Manufacturers of chemicals must provide SDSs for chemicals they sell. Laboratory staff and students must have access to SDSs or all chemicals used in the laboratory. EH&S recommends laboratories maintain paper copies of SDSs for the hazardous chemicals likely to spill and/or cause injury. Having an SDS immediately available when someone is exposed to a hazardous chemical aids emergency personnel in how to respond and treat that person.

14. CHEMICAL PROCUREMENT

Most chemical products can be purchased without restriction from suppliers through eProcurement. However, the following rules and guidelines apply to some chemicals:

15. Hazardous Chemicals

Order only the amount of chemicals needed. Many manufacturers will supply smaller quantities or containers. Do not stockpile chemicals. Chemicals that are expired and/or appear to be no longer useful are considered hazardous waste. Purchase hazardous chemicals in plastic-coated bottles (when available) instead

of uncoated glass bottles. Hazardous chemicals should be received directly by a laboratory or a chemical stockroom. If the chemicals are received in an office, there should be a safe location such as a designated table with adequate open space reserved for temporary storage of the package. When you open a shipment, you should verify that it is the correct chemical, that the container is intact, and that the date of receipt and label are legible.

Department of CLS must licenses radioactive materials use. Using radioactive materials requires prior approval from EH&S.

16. Highly Dangerous Materials

Materials that are extremely hazardous to property, health, or the environment (e.g., explosives, pyrophoric materials, highly water-reactive chemicals, and highly toxic gases, etc.) may not be procured until the necessary administrative, engineering and environmental controls are in place. Hazardous materials must be stored and used in accordance with numerous regulations.

17. Compressed Gas Cylinder Procurement

Gas cylinders should be purchased through the preferred supplier, Praxair, to ensure that the supplier has a cylinder return authorization program. Only order the amount of gas that you need. Some gas suppliers will not take returns of partially full or empty cylinders or containers. If a different vendor is necessary to provide a specialty gas, the purchaser must get a written return agreement from the distributor or manufacturer prior to purchasing the gas.

18. CHEMICAL STORAGE

19. Evaluate Chemical Hazards for Storage

Hazards due to the reactions between incompatible chemicals may include:

- Generation of heat
- Fire
- Explosion
- Toxic gas or vapor production

• Flammable gas or vapor production
• Formation of a substance with greater toxicity than the reactants
• Formation of shock- or friction-sensitive compounds
• Pressurization of closed vessels
• Solubilization of toxic substances
• Dispersal of toxic dusts and mists
• Violent polymerization

The general approach is to separate all chemicals into compatible groups. The specific SDS should always be consulted when evaluating chemical properties and hazards of the materials for storage. Most chemicals have multiple hazards; decisions should be prioritized as follows:

20. Flammability

The most important consideration for storage is the flammability characteristic of the material. If the chemical is flammable, it should be stored in a flammable cabinet. If the total for flammables exceeds quantity limits, they must be stored in a flammable's cabinet.

21. Reactivity

If the material will contribute significantly to a fire (e.g., oxidizers), it should be isolated from

flammables. If the material will contribute significantly to a fire when water is applied (e.g., water reactive chemicals), it should be stored to ensure it is protected from any contact with water, including water that would be applied while extinguishing a fire in the lab. Isolate materials that can react with themselves (e.g., polymerization).

22. Corrosives

Corrosive substances are chemicals that cause a reaction that lead to the damage of a solid

structure. A material is considered corrosive if a liquid or solid causes irreversible destruction of human skin at the site of contact within a specified period.

23. Toxicity

The toxicity of the material, with particular attention paid to regulated materials, means that certain chemicals will be isolated within a storage area. For example, an extreme poison that is also flammable should be locked inside the flammable storage cabinet.

24. Chemical Storage Practices

Establish and follow safe chemical storage and segregation procedures for your laboratory:

• Provide an appropriate storage place for each chemical and return the chemical to that location after use.

• Store in compatible containers.

• Incompatibles must not be stored together.

• Avoid storing chemicals on bench tops.

• Avoid storing chemicals in laboratory fume hoods.

Store volatile toxics and odoriferous chemicals in a ventilated cabinet (if available).

• Do not expose stored chemicals to heat or direct sunlight.

• Storage shelves should be level, stable, and secured to the wall or stable surface. In case of an earthquake, shelves should have raised edges or rim guards (minimum height: 2 inches) to prevent containers from falling shelves should be kept free of chemical contamination and dust sources.

• Containers should not protrude over shelf edges.

• Store heavy bottles on lower shelves; store corrosives below eye level ideally, cabinets and shelves should be sturdy and low to the floor and constructed of

material that is impervious (i.e. non-reactive) with the corrosive; they should also be ventilated or located near the
ventilation system.

• Containers of chemicals must be capped when not in use; make sure that caps on containers are secure; replace damaged caps.

• If a chemical does not require a ventilate cabinet, store inside a closable cabinet or on a shelf that is anchored and that has a lip to prevent containers from sliding off.

• Chemicals should not be stored under, near, or in the sink to minimize the chance of accidents and improper discharges to the sanitary sewer. Any vapours of corrosive materials and bases will cause corrosion of the plumbing fixtures under the sink. Some chemicals, including many corrosives, are water reactive and in the event of a water leak, there can be unanticipated and unfortunate consequences.

• Do not store chemicals in hallways, corridors or exit ways.

• If chemicals must be stored adjacent to each other on a benchtop, use secondary containment to prevent incompatible chemicals from mixing and reacting with each other.

• Use secondary containment or spill control, such as placing the container on an absorbent pad (generally required for containers on the floor).

• Particularly hazardous substances (highly dangerous or toxic chemicals, select carcinogens, mutagens, and teratogens) should be stored together if compatible.

• Signs should be posted indicating toxic chemical location and unique hazards

• Maintain the lowest possible quantities of highly toxics

• Chemicals with a high degree of toxicity (e.g., venoms, mycotoxins, and select agents), should be doubly contained and stored in a locked area accessible only by authorized personnel.

• Use containers that are chemically resistant and non-breakable Store chemical wastes (following the same guidelines as above)

• Waste containers must be labelled with a completed University of Washington hazardous waste label. If reusing a container that previously held another compatible chemical, the original manufacturer's label must be defaced. For more information about chemical waste.

• Use properly designed refrigerators or freezers for storing volatile flammables (certified by the manufacturer for flammable materials storage) which require refrigeration.

• If containers are placed in refrigerator/freezer door shelves, use secondary containers, additional barriers, Velcro or other protective measures to keep them from falling out when the door is opened.

• If chemicals are stored in a shared area or room, the storage space, cabinet or container should be labelled with the responsible party's name so that ownership can easily be identified.

Table 1 Chemical Storage Recommendations

Flammables	Store in approved safety cans or cabinets. Do not store incompatible materials in the same cabinet. Keep away from any source of ignition: heat, sparks, or open flames. Flammable solids must be segregated from flammable liquids
Acids	Do not store with flammable solvents or combustibles. Ideally, store in a cabinet designed for acids; do not store acids on metal shelving. Segregate inorganic from organic acids. Isolate nitric acid and perchloric acid from everything; including other perchloric.

Bases	Store in corrosives cabinet or on protected shelving away from acids. Segregate inorganic from organic bases.
Light sensitive chemicals	Store in amber bottles in a cool, dry, dark place
Nitrated compounds	Nitrated compounds can be considered explosive; special care and handling may be required.
Oxidizers	Store in a cool, dry place away from flammables and reducing agents. Oxidizers must not be stored on wooden shelves or in cardboard boxes.
Peroxidizable compounds	Store in airtight containers in a dark, cool place. Most peroxidizable compounds are flammable and should be stored in a flammable liquid storage cabinet. Label containers with receiving and opening dates. Test for the presence of peroxides at least every six months. Discard before exceeding expiration date. Inspect peroxide forming chemicals often for evidence of contamination, degradation, or any change from normal physical or chemical characteristics. If you suspect a material may have become explosive, contact EH&S immediately and post a warning sign so others do not handle or disturb the material.
Pyrophoric substances	Store in a cool, dry place, making provisions for an airtight seal. Materials (e.g., tert-butyl lithium) will react with the air to ignite when Exposed.

Toxic chemicals	Store according to the nature of the chemical, using appropriate security where necessary. Generally, store in a ventilated, dry, cool area in a chemically-resistant secondary container**.**
Water-reactive chemicals	Store in a cool, dry location away from any water source, including sprinkler systems. Have a Class D fire extinguisher available in case of fire.
Compressed gas containers	Store in a cool, dry place, preferable outside of the building and secured with a chain. Separate flammables and oxidizers by 20 feet or a 1-hour rated firewall.
General chemicals	Store on laboratory benches or shelves with like chemicals.

25. Flammable Liquids in Basements

Flammable liquids are also limited in basement rooms, to comply with the International Fire Code. The aggregate storage quantity in basement areas is limited to about half the amount of an equivalent above grade area.

26. Additional Requirements

Whenever possible, all flammable and combustible liquids should be stored within an approved flammable liquid cabinet. Small amounts, up to 10 gallons, may be stored outside of a flammable liquid cabinet under certain conditions. This includes the overall flammable load within the control area.

27. CHEMICAL LABELING

28. Original Container

The label on an original chemical container must be legible and written in English. It must include the chemical/product name as shown on the SDS and the manufacturer's name and address.

1. Product name

2. Manufacturer's name and contact information

3. Signal word (e.g., "danger", "warning" or no signal word)

4. Hazard statement(s) (e.g., toxic if inhaled, combustible liquid)

5. Pictogram(s)

6. Precautionary Statements (e.g., keep container tightly closed)

Avoid damaging the original container's label, if possible. If a container label becomes illegible, replace the label.

29. Labelling Stock / Working Solutions

Containers of preparations, sample aliquots and other working solutions are not required to be labelled if the container will be emptied before the end of the work shift and used by only one person. If a preparation or working solution is used by others, or kept longer than the day of use the container must be labelled with the following information:

• Identity of the contents (spell out chemical names)

• Signal word, if known or suspected (e.g., "danger", "warning")

• Hazards, if known or suspected (e.g., "flammable", "corrosive", "irritant")

30. Labelling Specialized Containers

Containers that are too small for labels, installed into a process or would become unusable for their intended purpose if labelled must still have their contents identified in some way. Use any labelling method that enables employees and visitors from other agencies, such as the fire department, to identify the chemicals and their hazards. Examples include a sign identifying the materials and their hazards, colour or numeric codes cross-referenced on a chart or room diagrams identifying locations of the chemicals and hazards.

31. Additional Label Required for Peroxide-Forming Chemicals

Label chemicals that form peroxides with the date the container was first opened, using the label code.

32. Additional Label Required for CFATS Chemicals

Label chemicals listed in the Chemical Facility Anti-Terrorism Standards (CFATS) with a warning label to remind workers that the substances are regulated and cannot be shipped off campus without prior EH&S notification.

33. Labelling Waste Containers

Waste containers must be labelled following the guidelines in this manual, for hazardous chemical waste. If re-using a container to hold waste, the container must be compatible and appropriate for the waste. Completely deface all old labels on containers used for wastes. Affix a new label.

34. TRANSPORTING CHEMICALS

Chemicals should be transported in a container that prevents leakage. The container should be closed. Avoid transporting chemical containers which may have contamination on the outside (i.e., avoid the need to wear gloves or other PPE while transporting chemicals). If the container is breakable, it should be placed in a secondary container.

1. Transporting between Floors and Buildings on Campus. This section applies to transportation by hand or by cart. In general, when possible, use freight- only elevators when moving chemicals between floors.

35. Moving a Single Chemical

1. The person doing the moving must be trained in the hazards of the chemical and know what to do in the event of a spill of that chemical.
2. The exterior of the container should be clean enough that it may be handled without the need for protective gloves.
3. Chemical bottles must be labelled and should be securely capped and placed in a bottle carrier.
4. Chemical containers that are glass and do not have closing caps or handles should be placed in bottle carriers or larger containers and surrounded by vermiculite or other absorbent material.

5. When moving a lecture bottle, do so in a manner that protects the valve. Larger gas cylinders must be moved using precautions.

6. Whenever possible, use freight elevators to transport chemicals. If no freight elevator I provided, passenger elevators may be used, but passengers should be discouraged from travelling with liquid and solid materials. Passengers (other than the material handler) are not allowed in elevators with compressed gas and cryogen transport.

36. Moving Multiple Chemicals

1. The person doing the moving must be trained in the hazards of the chemicals and what to do in the event of a spill of those chemicals.

2. The person must also have a spill kit that can handle the spill of those chemicals.

3. The exterior of the containers to be moved should be clean enough that they could be handled without the need for protective gloves.

4. Chemical containers must be labelled and securely closed. Lecture bottles should be packed in a manner that protects the valve.

5. Chemicals should be grouped by compatibility and by hazard class (e.g., flammable, toxic, etc.) and each group should be placed in larger containers or tubs while being transported.

6. Containers used to transport multiple chemicals should be lined with an absorbent material such as vermiculite to cushion the load and absorb and contain any spills. Multiple glass bottles in the same tub should be cushioned using the absorbent to prevent the bottles
from rattling against each other.

7. Carts used to move chemicals should be stable under the load and have wheels large enough to negotiate uneven surfaces without tipping or stopping suddenly.

37. Transporting Chemicals off Campus

EH&S is required to notify the Department of Homeland Security if you ship certain listed

substances governed by the CFATS.

38. SPECIAL CHEMICAL HAZARDS (PARTICULARLY HAZARDOUS SUBSTANCES)

Personnel need to take special precautions with chemicals that are reactive, explosive, highly toxic, select toxins, carcinogens and reproductive hazards, sensitizing or allergenic, synthesized chemicals, in compressed gas cylinders or at high pressure, that present exceptional flammability hazard, or have additional specific requirements due to federal regulations. If the degree of hazard is serious enough, the chemical is classified as a particularly hazardous substance.

Expanded precautions for use include:

• Improve the security and integrity of the chemical storage

• Review proposed procedures by another PI

• Intensive training on the chemical's hazards and the equipment used

• Require increased proficiency before any particular individual may

perform the procedures be demonstrated and documented

• Require a second lab worker be in the lab in case of emergencies

• Ensure all safety measures are included in the SOPs

• Check that additional measures for shipping such materials have been confirmed

39. Reactive Chemicals

A chemical is a reactive if it has the capability to undergo violent chemical change, such as explosions or production of toxic fumes, in certain situations. Purchase and use these chemicals in small quantities or find a suitable alternative. Take extreme care when handling and storing these compounds.

Chemicals with an National Fire Protection Association (NFPA) rating of three or four for reactivity are considered particularly hazardous substances, due to being highly dangerous. Extra precautions taken need to be documented in your SOPs.

a. Compounds that Generate Toxic Gases

Some compounds that contain sulfide or have a cyanide (-CN) functional group can generate toxic gases in sufficient quantities to present a danger to human health when combined with other compounds, such as hydrochloric acid.

Table 2 Toxic Gas Generators

Copper (II) cyanide	Mercury (II) cyanide	Sodium cyanoborohydride
1,4- Dicyanobutane	Methyl sulfide	Sodium dicyanoaurate (I)
Diethyl cyanophosphonate	Octyl cyanide	Sodium sulfide
Fumaryl chloride	Potassium cyanide	Toluene diisocyanate
Heptyl cyanide	Sodium cyanide	

40. Oxidizers

Oxidizers are chemicals that initiate or promote combustion of other materials. Oxidizing agents

include halogenated inorganics, nitrates, chromates, persulfates and peroxides.

Several accidents have occurred at the UW due to waste oxidizers being disposed into common

waste receptacles under the mistaken belief that the oxidizer would no longer react with the other

waste chemicals.

Table 3 Oxidizers

Ammonium dichromate	Lithium perchlorate	Potassium chlorate
Ammonium nitrate	Nitric acid	Potassium permanganate
Chlorine (liquid or gas)	Nitric oxide	Sodium nitrate
Chromic acid	Oxygen (liquid or gas)	Strontium nitrate
Guanidine nitrate	Perchloric acid	Sulfuric acid

41. Chemicals That May Polymerize

Polymerization is a chemical reaction in which small molecules combine to form larger molecules.

Polymerization can be hazardous when the reaction releases large amounts of energy or drastically

increases the volume of the chemical.

Table 4 Chemicals that may polymerize

Acrylic acid	Isopropenyl acetate	Vinyl bromide
acrylonitrile		
1,3-butadine	styrene	2-vinyl pyridine

42. Pyrophoric Chemicals

A chemical that will ignite spontaneously in air at or below 130 °F (54°C) is a pyrophoric. The

oxidation of the compound by oxygen in the air proceeds so rapidly that ignition occurs

spontaneously. Such chemicals would be considered particularly hazardous substances and the

extra precautions taken need to be documented in your SOPs.

Table 5 Pyrophoric Chemicals

Barium metal	Potassium metal	Sodium methylate
Lithium diisopropyl amide	Rubidium metal	Tert-butyllithium
Magnesium powder	silane	triethylphosphine
Methyl lithium	Sodium hydrosulfite	Tri-n-butylphosphine
Phosphorus sticks	Sodium methoxide	Trimethylaluminum

43. Water Reactive Chemicals

Water reactive chemicals react violently with water to release a gas that is either flammable or

presents a health hazard. Alkali metals, many organometallic compounds, and some hydrides react

with water to produce heat and flammable hydrogen gas. Some of these reactions proceed so violently that the chemicals are classified by NFPA as Reactive code three or four and the extra precautions taken (as described in Section G above) need to be documented in your SOPs.

Table 6 Water Reactive Chemicals

Alpha-toluenesulfonyl fluoride	Oxalyl chloride	Sodium metal
Antimony trichloride	Phosphorus oxychloride	Tert-butyllithium
Calcium hydride	Phosphorus pentachloride	Titanium (IV) chloride
Hydrobromic acid	Phosphorus pentasulfide	Trimethylchlorosilane
Lithium aluminium hydride	Potassium metal	

44. Potentially Explosive Chemicals

An explosive chemical, when subjected to heat, impact, friction, electric or chemical charges, can produce a sudden, quick release of pressure, gas, and heat. When detonated in an uncontrolled or unexpected circumstance, explosives can result in serious bodily harm or extensive property damage. Shock sensitive explosives are known to detonate, even when bumped or handled normally. Common potentially explosive chemicals at the UW include:

45. Nitrated Compounds

Nitrated organics and inorganics constitute the largest class of compounds that are explosive when dehydrated. When you purchase a nitrated compound, do so in small quantities. Weigh the container and note the weight on the bottle. Do not break the seal on the cap until the chemical is in active use. Prior to subsequent use, weigh the container again. If the container weighs less, add an appropriate solvent to replace the weight lost. After the reagent is opened and an aliquot is taken, again note the weight of the container. Visually inspect the container for problems prior to each use and wipe down the bottleneck, cap, and threads with a wet cloth before resealing.

Table 7 Nitrated Compounds

Diphenyl hydrazine	3-Nitrotoluene	Trinitrophenol (Picric acid)
nitrocellulose	Trinitrobenzene	Trinitrotoluene

Picric acid is a nitrated compound usually purchased as a solid wet with 10% water. Extreme heat, blasting cap, or electric charge can detonate picric acid. It becomes highly unstable if allowed to dehydrate. When wet, picric acid is an orange coloured, compact crystalline solid with the consistency of lumpy sand. When dry, picric acid is a crystalline solid with visible air pockets below the surface. Picric acid will readily form explosive metal picrates, which are extremely shock sensitive and will detonate with the slightest movement or vibration. Do not allow picric acid to contact metal that is readily oxidized or be stored in a container with a metal cap. Lead, iron and copper metals are particularly dangerous, due to metallic picrate formation.

46. Organic Peroxide-Forming Solvents

Organic peroxide-forming solvents become shock sensitive when allowed to oxidize and form appreciable quantities of explosive peroxides. Most of these solvents are also flammable. Most peroxide forming solvents are colourless, mobile liquids. Oxidation can occur when the solvent is exposed to atmospheric oxygen. This reaction is catalysed by light as well as by temperature and pressure changes.

Desired Procedures for Peroxides:

1. Highly Concentrated Peroxides - Over a period of time, peroxide concentrations can increase to hazardous levels. Solvents with high concentrations of peroxides will appear viscous or contain needle-like crystals. If peroxides are visible, no further handling is recommended.

2. Explosive Capability-Peroxides formed in organic solvents have caused some laboratory accidents, including unexpected explosions during distillation and use. Such formulations are considered low-powered explosives; they will detonate in moderate concentrations by modest shock, friction, or when heated. The biggest dangers of organic peroxides in these solutions are opening the container and distilling. Do not open or move the container if you see crystals on or around the container cap.

3. Required Procedures-Purchase peroxide-forming solvents in small quantities that contain an inhibitor, such as butylated hydroxytoluene (BHT), which will delay the formation of peroxides until the inhibitor is used up. Label the container with the date received and opened. Label the container with the standard peroxide label. Do not break the seal on the container until the solvent is needed. Once opened, store solvent in an airtight amber glass bottle or metal container, with an inert gas, such as nitrogen, in the headspace.

4. Testing Peroxides-It is a good laboratory practice to use test strips to test the solvent for peroxides prior to each use. After each use, wipe down the bottleneck, cap and threads with a cloth before resealing. Reduce formed peroxides and add an inhibitor (as necessary) to keep the concentration of peroxides below 10 ppm. Extreme caution should be exercised if concentrations of peroxides exceed 30 ppm.

5. Distillation and Evaporation Precautions - Always test for peroxides before distillation or evaporation because these procedures will increase the concentration of any peroxides present. Do not distil or evaporate solvents containing any amount of peroxides. Use a water bath over a hermetically sealed electrical mantle to safely heat the solvent. Use any distilled solvent immediately, or add an inhibitor.

6. Use of Inhibitors – Inhibitors slow the formation of peroxides in the future. They do not reduce or remove peroxides. Organic peroxides should be reduced safely.

7. Monitoring Expiration Date - Use the solvent before the manufacturer's expiration date. Peroxide-forming solvents exceeding their expiration date cannot be discarded through EH&S until the contents have been tested for peroxides.

Table 8 Peroxide-Forming Chemicals

Severe hazard	**High hazard**	**Moderate hazard**
3 months Once exposed to oxygen, rapidly oxidizes forming explosive	**6 months** Once exposed to oxygen, oxidizes at a moderate rate	**12 months** Once exposed to oxygen, slowly oxidizes forming explosive

peroxides.	forming explosive peroxides.	peroxides.
Diisopropyl ether Divinylacetylene Potassium amide Potassium metal Sodium amide Vinylidene dichloride (1,1- Dichloroethylene)	Acetaldehyde Cumene Cyclohexene Cyclopentene Diethyl ether Di-n-propyl ether p-Dioxane Furan Methyl isobutyl ketone Tetrahydrofuran Vinyl ethers	Ethylene glycol ethers Ethyl vinyl ketone Oleyl alcohol Tetrabutylammonium fluoride

47. Azides

Organic and inorganic azides, (R-N3), can explode when heated or exposed to ground glass joints.

Some azides are shock sensitive. Metal azides are relatively insensitive to shock, but may explode when heated. Sink disposal of azides can be extremely hazardous because they can form metal

azides that are shock sensitive, (like iron azide). Azides present a hazard around ground glass joints because they can be shock sensitive.

48. Fulminates

Fulminates are compounds that contain a carbon-nitrogen-oxygen group. Metal fulminates such as mercury, silver, and gold are highly explosive. Explosions

are typically initiated by heat. Silver fulminates can form in un-discarded Tollens reagent.

49. Highly Toxic Substances

50. Precautions for Use

In laboratories, particularly hazardous substances include chemicals that are highly toxic. The procedures for using such chemicals require additional precautions.

51. Categories of Highly Toxic Chemicals

Various regulatory agencies define highly toxic chemicals differently. The International Fire Code defines “highly toxic and poisonous materials” for signage and fire code reasons

52. Carcinogens and Reproductive Hazards

Additional care must be taken to minimize exposures to known and suspected carcinogens and reproductive hazard chemicals because inadequate information is available in many cases. Ways to minimize exposures include steps such as: substituting for less hazardous chemicals if possible, using the smallest amounts necessary, and using a fume hood or other control system.

53. Hazardous Drugs

Hazardous drugs, as defined and listed by the National Institute for Occupational Safety and Health (NIOSH), include those that exhibit one or more of the following six characteristics in humans or animals:

• Carcinogenicity

• Teratogenicity or other developmental toxicity

• Reproductive toxicity

• Organ toxicity at low doses

• Genotoxicity

• Structure and toxicity profiles of new drugs that mimic existing hazardous drugs. These include drugs used for chemotherapy (also called antineoplastics), antiviral drugs, hormones, some bioengineered drugs and other various drugs. Many of these substances do not have a known safe exposure or "no effect" level. Federal and state regulations and guidelines exist for the use, handling, storage, treatment and disposal of hazardous drugs in clinical and research settings. Follow safety precautions when working with hazardous drugs.

54. Sensitizing or Allergenic Chemicals

Potent chemicals, which can cause sensitization or allergy, may affect researchers by changing them style of life and, in some cases, force them to leave their areas of research. This hazard is not limited to traditional laboratory chemicals; researchers handling animals can become allergic to animal dander and researchers in forest resources can develop allergies to molds.

Table 9 Sensitizing or Allergenic Chemicals

Beryllium	Chromium	Isocyanates
1,2,4-Benzenetricarboxylic anhydride	diazomethane	latex
bichromates	formaldehyde	nickel
1,2-Cyclohexanedicarboxylic anhydride	glutaraldehyde	Phenols(certain types)

Once sensitized, a person may react to extremely low amounts of the chemical. Response can range from contact dermatitis to anaphylactic shock. Use caution to minimize exposures. Situations that may lead to an acute exposure (e.g., cleaning up a spill) should be carefully assessed to keep the exposure at a safe level. If a person is sensitized or allergic to a similar chemical any control, which will prevent exposure to the chemical should be implemented (e.g., improved ventilation, barriers, or improved procedures). If respirators are used, the person must comply with all steps in the UW Respiratory Protection Program:

55. Synthesized Chemicals

Synthesized chemicals may present unexpected hazards. The first step should always be to perform a literature review concerning the expected hazards from the proposed procedures and the hazards from chemicals with similar structure, taking into account that these hazards are being assumed. Pay particular concern to hazards from reactions or during purification or subsequent activities. Generate minimal quantities until the basic hazards of the chemical can be determined.

56. Nanoparticles

The term “nanoparticle” defines particles with at least one dimension less than 100 nanometres. They may be deliberately engineered or develop naturally. Such particles may be more reactive and toxic than bulk-size chemicals. Take special care to prevent them from being released into the environment. If your laboratory intends to create aerosolized nanoparticles, measure the typical nanoparticle levels before the process begins and compare to subsequent levels.

57. Compressed Gases, Gas Cylinders and Liquid Cryogen Containers Compressed

Gas is a generic term for describing: compressed gases, liquefied compressed gases, refrigerated liquefied gases (cryogenic gases) and dissolved gases. Non-liquefied compressed gases do not become liquid at normal temperature, even at high pressures. Refrigerated liquefied gases, also known as cryogens, be Liquefied compressed gases become liquid at normal temperatures when pressurized in a gas cylinder. come liquid at very low temperatures. The cryogenic gases have boiling points below -150°C. Dissolved gases are gases dissolved in other substances while stored in gas cylinders.

58. Hazards of Compressed Gases

1. Both physical and health hazards are present with use of compressed gases. The high pressure in cylinders (> 900 PSIG) makes the gas cylinder a potential physical explosive rocket that could punch through walls.

2. Some gases may be corrosive which could result in damage to tissue and/or equipment at the point of contact.

3. Cryogenic gases have dangerously low temperatures, potential frostbite and may expand into large volumes of gas that could displace oxygen and result in suffocation.

4. Inert gases and oxidizing reactions may create oxygen deficiency hazards (ODH) by displacing oxygen and may lead to suffocation. The early symptoms may be dizziness and weakness, which may lead to unconsciousness and death. This is also termed asphyxiation.

5. Flammability of gases, which could result in fires, is a concern especially for Acetylene, Hydrogen, and Propane.

6. The permissible exposure limits (PEL) for toxic materials may be very low, so even a small exposure could be poisonous.

7. Oxygen leaks may create oxygen-enriched atmospheres, which increase the risk of fire and explosions.

8. Additional hazards may be found on the gases' SDSs.

59. Safe Practices

Adhere to the following safe practices when working with compressed gas cylinders and cryogen

containers:

1. Make sure cylinders have proper labels including: contents, concentrations, hazard classifications, safety precautions, manufacturer or supplier's name, and a tag that indicates whether the cylinder is "full", "in-service", or "empty." Accept only properly identified cylinders. If the cylinder is not properly labelled, or the label cannot be read, return the cylinder to the supplier.

2. Make sure gas cylinders are not damaged and do not show sign corrosion. If you notice they have damaged labels, dents, gouges, burn/heat marks, or show signs of corrosion, then do not accept them and return them to the supplier.

3. Assume all cylinders contain gas under pressure and treat all gases as hazardous chemicals.

4. Clearly label all gas lines leading from gas cylinders. This is especially important if the cylinder cannot be seen from the application point.

5. Use, store and transport cylinders in an upright position unless they can be safely stored horizontally.

6. Make sure caps are in place when cylinder is not in use and during transport.

7. Make sure access to the cylinder valve is unobstructed at all times.

8. Make sure pressure regulators are equipped with pressure release valves.

9. Do NOT empty gas cylinders to a pressure lower than 25 psi (172 kPa). At lower pressures, suction and backflow can cause contamination of residual contents with air if the valve is open.

10. Do NOT use Teflon tape on cylinder or tube fitting connections, which have metalto-metal face seals or gasket seals.

11. When turning off the cylinder, turn the gas supply off at the cylinder valve first, depressurize the system and then turn off the regulator. If the cylinder will not be used for any period of time, remove the regulator and replace the cylinder cap.

12. Keep incompatible gases stored separately. If the cylinder is not in use, separate oxidizing gases from flammable gases by 20 feet or a one-hour firewall.

Note: one backup cylinder stored in the area with the one in use may also be

considered to be in use and not subject to incompatibility storage requirements.

13. Store highly toxic gases in exhausted enclosures (gas cabinet or fume hood).

14. Avoid sources of ignition and open flame.

15. Do NOT purchase more or larger cylinders than necessary.

16. Do NOT store flammable gases next to an exit or near oxygen cylinders.

17. Do NOT use or permit contact of solvents, oil or grease on cylinders or their valves.

60. Leaking Gas Cylinders

Do not over-tighten the valve in an attempt to stop the leak. If the valve continues to leak, consider

whether room evacuation and building evacuation is necessary. Take the following actions as

appropriate:

1. Flammable, oxidizing or inert gases – Wear PPE as necessary. If possible, allow the cylinder to exhaust into a well-ventilated area (such as a fume hood) with few or no combustible absorbent materials in the vicinity (such as cardboard). Post a sign warning of the leaking cylinder. Avoid sparks and open flames.

2. Toxic or corrosive gases – Wear PPE as necessary. Exhaust cylinder into an absorbent or neutralizer if possible. If no absorbent or neutralizing system is available, exhaust the cylinder into an operating fume hood. If escaping gas is leaking out of the control device or no control device is available, evacuate the area. Post a sign warning of the leaking cylinder.

61. Flammable and Combustible Liquids

Read the SDS for safety precautions before handling flammable and combustible liquids. Know the flash points of the flammable or combustible materials you are using. The flash point is defined as: “the lowest temperature at which a chemical can vaporize to form an ignitable mixture with air.” Many common organic solvents and chemicals used in the laboratory have flash points well below room temperature. At or above the flash point temperature, there can be sufficient vapor to ignite if an ignition source is present. Flammable

liquids are defined as: “having a flash point less than 100 °F (37.8 °C)”. Combustible liquids have a flash point of 100 °F or higher, but can still produce enough vapor to burn if heated. Highly flammable chemicals with an NFPA rating of four for flammability are also considered particularly hazardous substances.

62. Vapor Control

Use less hazardous chemicals if possible. Use the smallest amount of flammable liquid necessary for your procedure. Use closed systems whenever possible. If you must work with open systems, use a fume hood to prevent accumulation of flammable vapor. Close the fume hood sash when flammable chemicals are still present, even when not performing your procedure. Each flammable liquid has two limits: Lower Flammability Limit (LFL) and Upper Flammability Limit (UFL) defining the range of concentrations in mixtures with air that will propagate flames or explode. These limits are also sometimes referred to as the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL). The range that a fire or explosion could occur becomes wider with increasing ambient temperature and in oxygen enriched atmospheres. In Table 10 (below), Flash Points and Flammability Limits, flash points and the ranges of LFL to UFL are shown for typical laboratory chemicals.

Table 10 Flash Points and Flammability Limits of Certain Chemicals

chemical	**Flash Point °C / °F**	**Auto-Ignition Temperature °C / °F**	**Flammability Limits (% volume in air)**	
			Lower (LFL)	**Upper (UPL)**
Acetone	-37.8 / -36	465/870	4	60
benzene	-11.0 / 12	560/1070	1.3	7.1
Carbon disulfide	-30.0 / -22	80/176	1.3	50
Diethyl ether	-45.0 / -49	160/320	1.9	36
ethanol	12.8 / 55	365/690	3.3	19
methanol	11.1 / 52	385/725	6.7	36
Methyl ethyl ketone	-6.1 / 21	561/960	1.8	10
pentane	-40.0 / -40	260 / 500	1.5	7.8
Toluene	4.4 / 40	480 / 896	1.2	7.1

Section 3-Chemical Waste Management

Why Hazard Management?

Many potential hazards are associated with the storage and handling of laboratory chemicals. These hazards may be minimized by understanding the properties of the chemicals and by developing procedures by which they may be handled safely. Simply storing chemicals alphabetically is not prudent. Flammable, corrosive, explosive, and peroxide forming agents require precautions. Storing incompatible chemicals together may have disastrous results.

Guidelines for Chemical storage and Handling

A. **Chemical handling**:

Use bottle carriers to transport chemicals.

Close caps securely.

Pour all chemicals carefully.

Add acid to water, not water to acid.

B. **Labels**

Be sure all labels are securely attached and legible.

Keep chemicals in their original containers if possible.

Label all secondary containers to avoid unknown chemicals and/or inadvertent reaction.

Date all chemicals, which may become unstable over time or are peroxidizable.

C. Shelves

Do not store chemicals on hard-to-reach shelves.

Labels on stored chemicals should be able to be read easily.

Shelves should be made of a chemically resistant material and should have a 2-inch lip or

side rails.

D. Incompatible chemicals

Incompatible chemicals should not be stored together.

For each chemical, the hazardous nature must be considered individually and in relation to other chemicals in the area.

E. Excessive storage

Avoid stockpiling chemicals. Purchase only what is needed. Use older stock first

Discard chemicals that are no longer needed or that have expired.

F. **Fume hoods**

Fume hoods should not be used for storage of chemicals, unless the chemicals are part of the experiment being conducted in the fume hood at that time.

The exception is storage in a fume hood, which is specifically designed for that storage, and where experimental procedures are not carried out.

What qualifies as Hazardous Waste?

Chemicals or chemical mixture that exhibits any corrosive, flammable, toxic, reactive and/or persistent in the environment properties is, by legal definition

hazardous. some additional chemicals are managed as hazardous waste because they are carcinogenic.

In order to determine whether or not your chemical is hazardous, use your knowledge, the chemical's original label and/or the chemical's Safety Data Sheet (SDS) to determine if the waste is corrosive, flammable, toxic, reactive, persistent in the environment and/or mutagenic or carcinogenic, as defined in the below sub-sections.

1) Flammable/Ignitable

A waste chemical is flammable if it is one of the following:

• A liquid with a flash point less than 140 °F (e.g., ethanol, xylene or diethyl ether). The flash point is defined as "the lowest temperature at which a chemical can form an ignitable mixture with air" (by evaporating above an open beaker, for example.) The SDS typically includes information about the flash point if the chemical has one.

• A solid or gas capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture, or spontaneous chemical changes and burns so vigorously and persistently that it creates a hazard.

• A solid, liquid, or gas that evolves oxygen at room temperature or under slight heating (e.g., peroxides, chlorates, perchlorates, nitrates and permanganates.

2) Corrosive

A waste chemical is corrosive if it has a pH of less than 2 or greater than 12.5 (Note: a chemical is not allowed to be poured down the drain if it has a pH of less than 5.5 or greater than 12.

3) Reactive

A waste chemical is reactive if it is one of the following:

• A normally unstable compound that readily undergoes violent change (e.g., acrylonitrile, butyl hydroperoxide).

• When mixed with water, the chemical reacts violently, forms potentially explosive mixtures, or generates toxic gases in sufficient quantities to present a danger to human health (e.g., sodium metal, chloropropionyl chloride).

• The compound contains cyanides or sulfides that, when exposed to pH conditions between 2 and 12.5, could generate toxic gases in sufficient quantities to endanger human health (e.g., sodium sulfide, arsenic sulfide).

4) Toxic

There are many poisonous chemicals which causes prolonged illness or death while consuming either by swallowing, inhaling or absorbed by skin in a very small amounts. Specifically, Mercury metal and its compounds are toxic in nature. Permissible exposure limits (PEL) are specified by OSHA. Always check the warning and available information on the chemicals to determine its toxicity.

5) **Carcinogens**

These are cancer causing agents. According to OSHA standards these carcinogens are substances or mixture of substances which induces cancer or increase incidence.

Benzene and toluene are such carcinogens widely known. Ethydium Bromide used to visualize DNA in gel is also a potent mutagen. Students or faculty must carefully read the instructions on the label beforehand for preparation, usage and proper disposal of it.

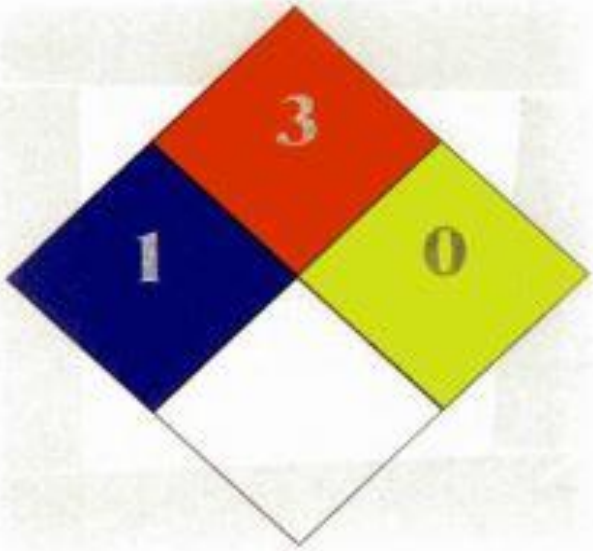
6) **Irritants**

These substances cause irritation, a reversible inflammatory effect on living tissue. Formaldehyde is one such irritant and potent carcinogen. Formalin, aqueous solution of formaldehyde is used in preservation of tissues and small organisms in intact state.

Common hazardous chemicals found in clinical laboratories include: Acetone, glutaraldehyde, acetic acid, isopropanol, any common concentrated acid (hydrochloric, nitric, sulfuric), methanol any common concentrated base (sodium hydroxide, ammonium hydroxide), toluene, Ethanol, xylene, formaldehyde etc.

National Fire Protection Association Hazard Labels

The National Fire Protection Association (NFPA) has developed a visual guide (right) for a number of chemicals pertinent to the MSDS. The ANSI/NFPA 704 Hazard Identification system, the NFPA diamond, is a quick visual review of the health hazard, flammability, reactivity, and special hazards a chemical may present. The diamond is broken into four sections (blue, red, yellow, and white). The symbols and numbers in the four sections indicate the degree of hazard associated with a particular chemical or material.



Health Hazards *(blue)*:

0 = No hazard.
1 = Can cause irritation if left untreated.
2 = Can cause injury. Requires prompt treatment.
3 = Can cause serious injury despite medical treatment.
4 = Can cause death or major injury despite medical treatment.

Flammability *(red)*:

0 = Will not burn.
1 = Ignites after considerable preheating.
2 = Ignites if moderately heated.
3 = Can be ignited at all normal temperatures.
4 = Very flammable gases or very volatile flammable liquid.

Reactivity *(yellow)*:

0 = Normally stable. Not reactive with water.
1 = Normally stable. Unstable at high temperature and pressure. Reacts with water.
2 = Normally unstable but will not detonate.
3 = Can detonate or explode, but requires strong initiating force or heating.
4 = Readily detonates or explodes.

In the diamond designated *other* ***(white)*** one might use the following descriptions:

OX = Oxidizer.
ACID = Acid.
ALK = Alkali.
COR = Corrosive.
W = Use no water.

Precautions for Chemical Safety

- Review the safety and health hazard data of all chemicals used in the laboratory.
- Know the signs and symptoms of overexposure and the physical and sensory characteristics (odor, appearance) of these chemicals.
- Know appropriate procedures for emergencies, including the location and operation of all emergency equipment.
- When working with hazardous materials, have a second person nearby, or, at minimum, maintain surveillance by telephone contact.
- Avoid leaving experiments unattended.
- Never use unlabeled chemicals or chemicals whose labeling is suspect.
- Always order the least amount of chemical required.
- Use appropriate personal protective equipment at all times.
- Use hazardous chemicals in a chemical fume hood, whenever possible
- Maintain equipment and inspect it regularly for proper function.
- Use guards and shields where possible.
- Store and handle chemicals in accordance with the guidelines contained in the Chemical Hygiene Plan or in accordance with the chemical manufacturer's guidelines.
- Store hazardous waste in a closed, labeled container.
- Dispose of hazardous waste through the University Hazardous Waste Program.
- Avoid pouring chemical waste materials into the sink. 19. Do not eat, drink, smoke, chew gum or apply cosmetics in the laboratory.
- Do not store food or beverages in the laboratory or in a chemical refrigerator.
- Do not mouth pipette. Use a mechanical pipette or aspirator.
- Do not use chipped or cracked glassware.

- Report all accidents, even if they do not result in injury.

Safety symbols

 Harmful or Irritant	 Flammable	 Explosives	 Oxidizing
 Corrosive	 Environmental Hazard	 Respiratory Protection Sign	 Gloves Required Symbol
 Eye or Face Protection Symbol	 Protective Clothing Sign	 Protective Footwear Sign	 Eye Protection Required
 Ear Protection Required Sign	 Danger Sign	 Caution Sign	 Fire Extinguisher Sign

 Black/White Fire Extinguisher	 Fire Hose Safety Sign	 Flammable Gas Symbol	 Nonflammable Gas
 Chemical Weapon Symbol	 Biological Weapon Symbol	 Nuclear Weapon Symbol	 International Biohazard Symbol
 Prohibition Symbol	 Non potable Water Symbol	 Do Not Touch Sign	 No Open Flames Sign
 Do Not Eat or Drink Sign	 Do Not Enter Sign	 Reactive Material Symbol	 Carcinogen Hazard Symbol

Low Temperature Warning Symbol

Hot Surface Warning Symbol

Magnetic Field Symbol

Optical Radiation Symbol

Laser Warning Sign

Compressed Gas Symbol

Non-Ionizing Radiation Symbol

Generic Warning

Ionizing Radiation Symbol

Remote Control Equipment

Biohazard Sign

High Voltage Warning Sign

Toxic Chemical Symbol

Laser Radiation Symbol

Blue Important Sign

Yellow Important Sign

 Red Important Sign	 Radioactive Symbol	 Radiation Warning Symbol	 Poison Sign
 Dangerous When Wet Sign	 Orange Biohazard Sign	 Recycling Sign	 Chemistry Hazard Label
 No Open Flames	 Toxic Materials Sign	 Explosive Material Sign	 Flammable Sign

Hazardous Waste Storage and Disposal

Regulations require that hazardous wastes be accumulated and stored in properly managed containers on sufficiently impervious surfaces (free of cracks, gaps, etc.).

Biohazard wastes are classified into various categories:

1. **Cultures and stocks of agents infectious to humans** (including human, primate, and mammalian cell lines), associated biologicals (e.g., serums, vaccines, antigens, toxins), and culture dishes and devices used to transfer, inoculate or mix cultures (e.g., Petri dishes, vials, filtration devices, flasks, inoculation loops, disposable gloves).
2. **Human pathological wastes** including tissue, organs, and body parts, and specimens of body fluids and their containers. This does not include urine or fecal material.
3. **Human blood and blood products** including serum, plasma or materials saturated with human blood. Excludes feminine hygiene products.
4. **Sharps** such as syringes and needles, razor blades, scalpels, blood vials, Pasteur pipettes, etc. Also includes broken or unbroken glass (culture tubes, flasks, beakers), glass slides, or cover slips that have been in contact with infectious material.

5. **Animal wastes** including carcasses, body parts, body fluids, blood, or bedding originating from animals known to be contaminated with (zoonotic organisms) or intentionally inoculated with infectious agents. Excludes preserved animals used for educational purposes.

Note: Biohazardous wastes must not be mixed with chemical or radioactive waste, or with other laboratory trash.

Cultures and other solid wastes Storage

Place cultures and stocks of infectious agents, other biologicals, and non-sharps items contaminated with biohazardous materials into red bags that have the biohazard symbol or the word "BIOHAZARD". Use double bags if necessary to prevent leakage.

Sharps

Collect all sharps items in approved rigid, leakproof, and puncture-resistant containers that are prominently labeled with a universal biohazard sign and the word "BIOHAZARD". To prevent contamination and potential injury, dispose of needles and syringes directly into a sharps container without any further manipulation (e.g., NO clipping, bending, breaking, shearing, or recapping). Devices that clip off the needle are prohibited. Dispose of the sharps container when ¾ full.

S

Drain Disposal

Liquid wastes that contain infectious agents, cell culture waste, blood, or other bodily fluids, must be chemically treated with bleach (e.g., 1:10 final dilution of bleach) or autoclaved (steam sterilized) prior to disposal to a sanitary sewer. Do not discharge large volumes of blood or fecal matter in the sanitary sewer as this may plug the drain and may place maintenance personnel at risk.

Chemical Hazard Storage and Disposal

- **Storage**: Hazardous waste in laboratories must be stored in satellite accumulation areas.
- **Disposal**: Once a satellite accumulation area container is filled, it must be dated and transferred to a main accumulation area or shipped off-site within 3 days. Environmental, Health and Safety is available to provide waste pick up services. Disposal of hazardous wastes and chemicals in laboratory sinks is prohibited by regulation.
- **Labeling**: Containers that accumulate and store hazardous waste must be labeled with the following information
  - ✓ The words "Hazardous Waste".
  - ✓ The waste type in words (Spent non-halogenated Solvents, Waste Oil, etc.).
  - ✓ The associated hazard in words (i.e. ignitable, toxic, etc.) and
  - ✓ The date upon which the container became filled.
  - ✓ Containers must be labeled and situated so that labels are clearly visible.
- **Closure**: Containers must be closed at all times, unless waste is being added or removed. Open-top funnels may not be left in open containers.
- **Condition**: Containers must be in good condition. There may not be severe rusting, dents or other conditions that could cause leaks, etc.
- **Compatibility**: Containers must be compatible with hazardous waste stored within them. When in doubt, use the original shipping container.

- **Inspections**: Containers must be inspected weekly by laboratory personnel to ensure that they are properly labeled, in good condition and meet the criteria described above.

Hazardous waste minimization

Laboratory waste minimization techniques include:

- Process/equipment adjustment or modification;
- Toxic material substitution;
- Waste segregation and separation; and
- Recycling where possible, microchemistry will reduce waste volume and has the added benefit of minimizing health and safety concerns.

In a chemical emergency

- Splash to Skin or Eyes.
- Flush with water at least 15 minutes using a safety shower or eye wash and seek immediate medical attention.
- **Injection**: control bleeding, wash with soap and water and seek immediate medical attention.
- **Ingestion**: call Poison Control and seek immediate medical attention.
- **Inhalation**: stop emission if possible, alert others or sound alarm, get fresh air and seek immediate medical attention.

Section 4 :-Laboratory Equipment and Facilities

Emergency Equipment's like Eye wash and Showers

Emergency washing equipment is required when using corrosives (acids and caustics), strong irritants (which cause inflammatory effects upon contact) and toxic materials that can be absorbed through the skin. Emergency washing facilities must be accessible to the person and he should be able to reach the equipment within 10 seconds.

1) Eye wash stations

Eyewash stations are the most important equipment especially in the labs near to chemical hood or working station. Chemicals can cause blindness or instant pain. These small amount of chemicals spill or splash causes eye damage. Laboratory staff/students should be able to reach eyewash stations within 10 seconds. There should be no obstruction in the path of eye wash stations.

Instructions for laboratory personnel

- Should know the location and operation of the eyewash stations in their area.
- It is recommended that personnel practice locating the eyewash station while keeping their eyes closed.
- Don't work alone when working with the hazardous chemicals.
- Ensure the weekly inspection of eyewash area.

- During the weekly check, the eyewash should be operated long enough (30-60 seconds), so that there is no visible rust or contaminant in the water. If the eyewash is located in a shared area, an individual should be appointed to perform the weekly test.

2) Safety Showers

Lab Incharge/students should be aware of the location and use of emergency showers in their area and should able to reach them in less than 10 seconds. Path to the emergency shower and the area underneath it should always be clear.

Facility services of the department provides with annual safety shower testing. Equipment has a tag on it which shows the most recent testing date.

Fire Safety Equipment

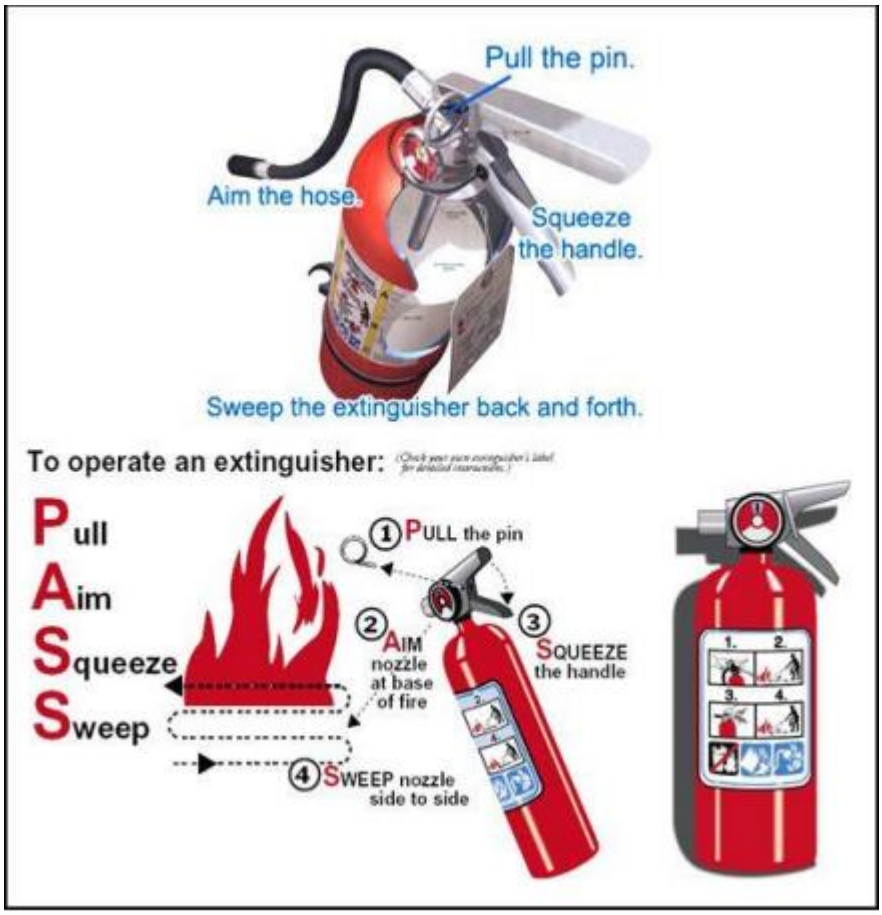
Fire extinguishers

Fire extinguishers are installed in every nook and corner of the department as well as the college building to be used by trained personnel.

Laboratory staff must be trained to use fire extinguisher with complete knowledge of hazards involved. Individuals not trained with no knowledge of extinguisher should not attempt to use them during fire.

Fire extinguishers are wall mounted and easily accessible. Regular maintenance of the extinguishers are done annually by the formed safety committee of the department and college.

Operation of a fire extinguisher: PASS rule



Emergency procedures for laboratories

Emergency phone numbers are mentioned in the lab for different emergency situations. Contact the person in charge in case of accident, spills or any other emergency.

LABORATORY VENTILATION

Fume Hoods

These are one of the ventilating equipment which seizes, holds and exude discharge triggered by chemical processes. In other way to control airborne chemical exposure. These are used with compounds with boiling point below 120 C or toxic.

Lab incharge should be trained for the use of fume hood. Sliding slashes in a fume hood are for better protection from unexpected chemical reactions. Periodic maintenance of hood is required. Staff need to coordinate with lab head member for required maintenance.

Glove box

Gloves protect the user from a variety of hazards including contact with infectious agents, contaminated surfaces or equipment, and animals. Employees must select a glove based on the particular tasks, as no one type of glove can adequately protect against every kind of hazard. Additionally, you should consider an alternative glove material (e.g., nitrile, vinyl) if you are sensitive to latex.

Disposable gloves (e.g., latex, nitrile, vinyl) offer little protection against needle sticks or animal bites, and so it is important to follow good microbiological practices and procedures to maintain an envelope of protection. Specialty gloves such as Kevlar or stainless steel mesh gloves can be worn during necropsy or surgery of infected animals to prevent accidental cuts from scalpels. Gloves should be long enough to cover the cuff or lower sleeve of laboratory clothing and protect exposed skin. Double gloving can provide additional protection. Remove disposable gloves and discard in biohazard waste

containers when work with infectious or biohazardous material is completed. Do not wash or reuse disposable gloves. Heavy-duty latex and nitrile gloves can be decontaminated, washed, and reused if in good repair. Remove gloves when performing non-laboratory functions (e.g., answering the telephone, using the computer), or operating outside the laboratory (e.g., pushing elevator buttons, turning doorknobs). Always wash hands after removing gloves. Environmental Health & Safety can assist with proper glove selection.

Biological Safety Cabinets

Biological safety cabinets (BSCs) are laboratory hoods designed to protect the worker and the experiment by drawing air across the samples and away from the worker and into a HEPA filter. There are two classes of BSCs. Class II type A and Class II type B1 units recirculate filtered air into the laboratory and are not designed for chemical use for this reason. The Class II type B2 unit is designed for use of some chemicals but is not substitute for a fume hood. The use of chemicals in this type of hood needs to be evaluated carefully so that the protective barrier (HEPA filters) is not destroyed by the chemicals.

Laminar Flow Hoods

Laminar flow hoods are designed to protect the employee/student's work surface from contaminants and may blow out into the face of the person using the hood. Therefore, any chemical use will cause the person to be exposed to the chemical. Toxic or volatile chemicals may not be used in a laminar flow hood.

Cold Rooms

Cold rooms are generally closed with no fresh air and are designed for designated purposes. These should be fitted and designed such that any person trapped or locked can exit the area easily. Should have independent power supply with respect to departments to allow light at all times whenever needed. Chemicals which require low temperatures are stored in these rooms.

Flammable solvents should be avoided as ignition sources could ignite vapors. Avoid volatile acids too as can cause corrode the cooling coils.

Maintenance of ventilating systems

Ventilating systems should be routinely maintained for any leaks or blocks. Filter need to be replaced periodically. Keeping a record of this is mandatory. Monitor the devices for malfunction and should understand the alarm signal and take necessary action if required.

LABORATORY APPARATUS AND EQUIPMENT

General Lab safety practices

- Wear PPE recommended by the manufacturer when using the equipment, along with safety goggles and gloves. (i.e.: hearing protection, face shield, etc.).
- Keep the manufacturer's operating manual with the instrument.
- Record of maintenance should be followed.
- Lab incharge should be trained and familiarize about operating manual and safety information.
- Avoid removing any warning or hazardous labels from instrument.

- Instrument should be grounded properly.
- Disconnect from main power source if instrument is not in use and when conducting maintenance.

Refrigerators, freezers and cold rooms:

During a breakdown, do contact the dedicated repair mechanic. Avoid modification or repair by laboratory incharge. Refrigerant gas must be collected and recycled.

Every refrigerator (4 C), Freezer (-20 C), cryofreezer (-80 C) must be labelled indicating the storage of samples or chemicals. Proper monitoring of refrigerator must be done to ensure that no loss of samples or chemicals takes place in fluctuating power supply.

Flammable liquids must be stored in a dedicated flammable safe refrigerator and should be kept separate.

Stirring and mixing equipment:

Commonly found stirring equipment's in laboratories are magnetic stirrers with heat, shakers etc. proper care needs to be taken when using these devices as they cause electric sparks. Check for the balance, temperature, rpm in a shaker. Avoid any spills inside the shaker hood. Disinfect with alcohol after every experiment performed.

Heating equipment (Ovens, Hotplates)

Basic labs are equipped with heating devices like ovens, hot plates, water baths, microwave ovens. Avoid Bunsen burners, instead we can replace it with

Bacticenerator for sterilization purposes. Monitoring should be done weekly or monthly to check for proper functioning of heating device.

Precautionary measures should be followed for safety when working with heating devices. Repair or replace the damaged equipment.

Centrifuges

These are one of the basic in any laboratory systems. These need to be properly installed and on a balance working bench. Check for the lid if its properly closed when in motion. Emergency stop should be available along with disconnect switch to shut the equipment.

Weighing

Weighing balance (digital, electronic) are available in every lab for measuring smallest amounts of raw materials. Keeping in mind the boats or container to weigh should not react with material being weighed. Keeping it clean at all times. Calibrate periodically.

Autoclaves

Proper training is required for both staff and students before operation. Check the drain before and after use. Knowledge of appropriate containers to autoclave. Check water level before every autoclave session. Reporting any spills or leaks to lab incharge.

Decontamination of work areas

Laboratory incharge is responsible for providing a clean and unobstructed work area for all maintenance and service personnel. Floors should be cleaned regularly and kept free of obstructions.

If an equipment requires service or maintenance by the technician/mechanic, ensure the area/equipment is unobstructed, emptied of chemicals, decontaminated, washed with warm, soapy water and rinsed.

If laboratory incharge is unable to attend service personnel on a scheduled time, leave a note stating a contact name and phone number in case there are questions about the work.

Decontamination of equipment for disposal

Laboratory equipment's are often contaminated with hazardous materials and/or may be inherently unsafe for further use.

Examples of equipment that must be decontaminated include: BSCs, bins and tanks, centrifuges, cryostats, fume hoods, freezers, Incubators, lockers, ovens, refrigerators, sinks, storage cabinets etc.

Some equipment may contain transformers, such as x-ray equipment and electron microscopes. Oil must be drained off for decontamination purpose, refueling oil will be tested and certified by the environment health and safety guidelines.

Decontaminate equipment used to process chemicals

Drain the chemicals from the equipment, including any oil or coolant. Collect the chemical for reuse or dispose of as hazardous waste. Use an inert gas or liquid to purge or rinse out chemical residues, if applicable.

Decontaminate the equipment using solvents to remove viscous or non-water soluble contaminants. Then scrub decontaminated equipment thoroughly with warm, soapy water. Rinse and dry. Wash and/or rinse water and solvents may need to be managed as hazardous waste.

Decontaminate equipment used to process biological samples

Remove all biological material (samples) from the equipment. Decontaminate with a 1:10 bleach solution. After 30 minutes of contact time, rinse metal surfaces.

Before repair or relocation, biosafety cabinets (BSCs) must be decontaminated following health and safety guidelines.

Section 5 -Employee Health

Good laboratory practice helps to minimize the exposure from certain chemicals and infectious materials, as it is unclear for certain chemicals toxicity.

Organizations for following Guidelines

- National Institute for Occupational Safety and Health (NIOSH)(Recommended Exposure Limits- RELs)
- American Industrial Hygiene Association (AIHA)-(Workplace Environmental Exposure Limit Guides (WEEL Guides)
- Saudi Central Board for accreditation of Health Care Institutions – CABAHI
- Ministry of Health-Saudi Arabia
- Saudi Food & Drug Authority.

Routes of Exposure to chemicals and infectious materials:

- Airborne Exposure results from procedure that generate air contaminants outside of fume hoods/laminar flow, volatile chemical spillage/ gas leak, microbial cultures (aerosol)
- Inhalation –ingestion,
- Direct skin or eye contact (mucus membrane)
- Injury of skin by a sharp object and/ or high-pressure source.

Example for signs of exposure

Headaches, rashes, nausea, coughing, tearing, irritation or redness of eyes, irritation of nose or throat, dizziness, and loss of motor dexterity or judgment

and these conditions should be evaluated if there is no pathological cause for such symptoms. Follow-up is especially important in these cases.

Contact Emergency numbers

Emergency in the University campus—---------950/011 4671079

Chamber of the University's operations--------4677866/4676298

Civil Defense inside the University campus----955

Civil defense outside the university campus----998

KSU Ambulance----------011 4699999

King Khaled Hospital ambulance----------4671699

Alternate Director----------4673128

Safe Work Practices

- Keeping the laboratory clean, organized, and functioning properly can help to prevent incidents and injuries.
- Easy access to exit way and emergency equipment (like eyewashes, drench hoses, and safety showers) without obstruction
- Always keep the work area clean with equipment and hazardous materials properly placed/stored.
- Keep drawers and cabinets closed and cords & cables off the floor with proper placement to avoid tripping hazards, falls and it will help in easy cleaning.
- Promptly clean up spills and dropped materials to avoid slip hazards

•Maintain sink traps and floor drain traps filled with water at all times to prevent the escape of sewer gas into the laboratory.

•Keep sharp or pointed tools properly sheathed or otherwise stored safely when not in use.

•Clothes should be hanged in proper locations without dropping over equipment or benches.

•Do not store excess cardboard/ equipment boxes or lab equipment under lab benches or above shelves/cabinets throughout the lab. This can be a safety as well as a fire hazard

- Regular maintenance of the equipment is essential, if equipment is not functioning properly label as "out of service" until the repair is completed.
- Proper biosafety cabinet should be used for specific type of the work

Ex: Biosafety level- (BSL-1) is for All bacterial, parasitic, fungal, and viral agents having minimum risk.

Biosafety Level 2 (BSL-2) for work involving infectious agents that pose moderate hazards to personnel and the environment. Handling personnel must be well trained and should have restricted access to others while working.

Biosafety Level 3 (BSL-3) has special engineering and design features for handling indigenous or exotic agents that may cause serious or potentially lethal disease through the inhalation. Laboratory personnel must receive specific training in handling pathogenic and potentially lethal agents,

Brief details mentioned in below table.

BSL	**Agents**	**Practices**	**Safety Equipment (Primary Barriers)**	**Facilities (Secondary Barriers**
1	Non-pathogenic	Standard microbiological practices	None required	Open bench top, sink required

2	Can lead to human disease via percutaneous injury, mucous membrane & ingestion	BSL-1 + limited access and biohazard warning signs • waste decontamination process	BSL I/ II for agents that generate splashes/ aerosols of infectious materials+ PPE (lab coats, gloves, face protection)	BSL-1 + easily cleanable furniture + autoclave available + eyewash available
3	Indigenous or exotic agents with potential for aerosol transmission; disease may have serious or lethal consequences	BSL-2 practices + controlled access + decontamination of all wastes & lab clothing	BSL I or II +PPE: lab coats, gloves, respiratory protection	BSL-2 + physical separation for corridor access + hands-free handwashing-sink, eyewash + exhaust air not recirculated + negative airflow into laboratory
4	Dangerous/exotic agents which lead to life-threatening disease +	BSL-3 practices plus: • clothing change before entering	All procedures conducted in BSL III or Class I or II in combination	BSL-3 plus: • separate building or isolated zone

	aerosol-transmitted lab infections or unknown risk of transmission	• shower on exit • all material decontaminated on exit from facility	with full-body, air supplied positive pressure suit	• dedicated supply/exhaust, vacuum and decon system

Section 6-Personal Protective Equipment (PPE)

The purpose of PPE is to minimize student and employee exposure to laboratory hazards. Ex: gloves, eye and foot protection, respirators, and protective clothing such as aprons and lab coats.

- Laboratory managers should monitor and assess the risks of exposure to hazardous/Infectious material based on the procedures performed in the laboratory.

Hazards and Example PPE

Hazard	**Personal protective equipment**
Biohazards	Gloves, lab coats, liquid resistant surgical masks, aprons, sleeve covers, face shields, splash goggles
Chemicals	Gloves, chemical-resistant clothing, aprons, sleeves and shoe covers, vapor- proof splash goggles; lab coats for general use
Cuts/Abrasions	Cut-resistant gloves (leather, Kevlar, chain-mail)
Explosions	Protective vests, face shield
Radiation	Lead apron, lead gloves, thyroid collar, lead glasses for X-ray, lab coats/gloves for radioactive materials
Splashes	Splash goggles, face shields, chemical-resistant clothing, gloves, aprons, sleeves and shoe covers

Guidelines to be followed while working in the laboratory:

- Lab coats and appropriate eye protection always be worn when working in the laboratory as best practice.

- In addition to safety glasses or splash goggles, face shields will provide maximum protection to the face and neck from flying particles and harmful liquids.
- Feet must be covered fully with proper Shoes without any opening or mesh and complete cover of legs (Clothing- Preferred materials - cotton, wool, and resistant polyester).

  Synthetic materials, (acrylics, rayon, and polyester) are not recommended.
  - Avoid loose, flowing garments, scarves and Loose jewelry (bracelets, watches and necklaces).
  - Avoid rings that can damage protective gloves or make removing gloves difficult.
  - Tie long hair to avoid caught in equipment, chemicals contact or field of view interference.
  - Wear long, loose-fitted, Flame-resistant laboratory coats and always button completely for skin protection and cloths from splatter and spills.
  - All Lab coats and other protective wear used in a lab should be kept in the work area to minimize the possibility of spreading chemicals to public places (including eating or office areas).
  - Laboratory coats must be laundered when soiled based on frequency of use.
  - Wear right size gloves whenever working with chemicals, biohazards, radioactive materials, rough or sharp-edged objects or very hot or very cold materials and discard discolored/ punctured gloves.
  - Be cautious while wearing gloves and avoid wearing gloves while touching common surfaces (Ex: telephones, computers, door knobs, elevator buttons) as they can be touched by others without gloves and outside the laboratory.

- Do not re-use disposable gloves and dispose contaminated gloves in a plastic bag carefully.
- Do not wear latex gloves in the lab as they provide very little protection from chemicals and can be the source of allergic reactions
- Standard Operating Procedures_(SOPs) should maintain having all the details of safe laboratory procedures, integrated into a protocol, when involves the use of hazardous substances along with the details of handling& storage procedures & with situations of Spill and Accident, waste disposal procedures.
- SOP document should include details like precautions for animal use, administration of the chemical, aerosol suppression, protective equipment and waste disposal decontamination procedures,
- laboratory equipment is provided with a manual that includes safety warnings, the manual (or at least the safety warnings) must be accessible to laboratory personnel. Do not remove labels indicating possible electrical shock, sharp edges, or pinch points
- Chemical Inventory must be maintained and all workers must know where the inventory is maintained

Section 7-SAFETY TRAINING REQUIREMENTS

Mandatory laboratory-specific hazard awareness program should conduct by lab in charge to all employees or student.

Training should include

•The location and contents of the Laboratory Emergency Response

•Location of emergency equipment such as fire extinguishers and fire alarm pull stations.

•Proper use and disposal of sharp objects (including broken glass disposal boxes).

- Lab in charge responsible for ensuring that all employees receive adequate training to understand the hazards in their work area.
- Training must occur prior to assignments involving potential exposure to chemicals/pathogens.

Risk Minimization can be done by

- Using a non-flammable/non-toxic substitute for your material is available.
- Using a minimum amount of the material
- Keeping containers securely closed and properly disposing of unnecessary or outdated chemicals. (proper disposal)
- Maintain poster having details of emergency phone numbers and the Exposure Response
- Identify the locations of emergency equipment on a floor plan; make sure all staff know the locations of the equipment, such as a spill kit/ first aid kit

General Purpose Chemical Spill Kit Contents

Item	Description
Absorbent	Five spill pads, universal for acid, base, oil, solvents
Neutralizer	One 64 oz. box baking soda for neutralizing acids
Brush, dustpan	One snap together dust pan and whisk broom
Plastic bags	Four 18 x 30, yellow hazardous material heavy duty waste bags
Plastic drum	One 5-gallon re-useable screw top plastic drum to store kit supplies and hold bagged spill waste
Goggles	One chemical splash protection goggles
Impervious gloves	One pair Silvershield gloves (multi-layer construction, impervious to most chemicals
Lightweight gloves	Eight pairs of Microgrip powder-free nitrile gloves, various sizes

Biohazardous Spill Kit

Assemble the following items in a single container than can be easily moved to a spill area.

An appropriate chemical disinfectant	•A freshly prepared 1:10 dilution of household bleach, or•Other decontaminant appropriate for agent in use
Material to absorb liquids	•Paper towels,•Absorbent lab pads, or•Any other special materials designed to absorb large volumes of liquid
Personal protective equipment (PPE)	•Nitrile or heavy duty gloves,•Long-sleeved lab coat or gown,•Safety glasses or goggles,•Facial protection for large spills, and•Any additional PPE required for agen
A mechanical means to pick up broken glass	•Tongs,•Forceps,•Scoops,•Sponges,•Autoclavable dust pan, or•Any other method that prevents direct contact with broken glass
Containers for treatment and disposal	•Biohazard bags for clean-up waste,•Sharps container for broken glass, and•Plastic bucket or other secondary container for transport

- easily accessible First Aid Kits to lab staff at all times having absorbent compresses, adhesive bandages, adhesive tape, antiseptic wipes, burn ointment, exam gloves, sterile pads and triangular bandages.
- Accidents Causing Serious Personal Injury or Exposure call 911 for emergency response as soon as possible while conducting the following first aid responses as appropriate.
- If a hazardous chemical gets in someone's eyes, flush eyes for at least 15 minutes in the eyewash while holding the eyelids open

- If natural gas leakage in the laboratory turn off all sources of ignition (open flames, electrical equipment).

Decontamination

A decontamination procedure can range from sterilization to simple cleaning with soap and water making a hazardous material safe for further handling. Process of decontamination includes

Heat: Wet heat/ Steam autoclaving is for decontaminating biological waste and sterilizing glassware and media.

Liquid Disinfection: surface decontamination agents include ammonium compounds, phenolic compounds, halogens, aldehydes, alcohols , amines and 10% household bleach.

Vapors and Gases: category include ethylene oxide, formaldehyde, gas, hydrogen peroxide and peracetic acid for decontamination of biological safety cabinets, whole building or room

Radiation: Ultraviolet radiation (UV) is used in biological safety cabinets for inactivating contaminants

Decontaminants and Their Use in Laboratories

decontaminant	Active Ingredient/ Concentration	Temp (°C)	Contact time (min.)
Autoclave	Steam	121	50–90
Incinerator	Heat	649-929	1-60
Phenolic compounds	0.2-3%		10-30

Chlorine compounds	0.01-5%		10-30
Alcohol (ethylor isopropyl)	70-85%		10-30
Formaldehyde	4-8%		10-30
Gluteraldeyhyde	2%		10-600
Hydrogen peroxide	6%		10-600

WASTE MANAGEMENT

- ✓ Biological waste disposing includes autoclaving, incineration, and chemical disinfection.
- ✓ Sharps — Needles, syringes with attached needles, capillary tubes, slides and cover slips, scalpel blades, razor blades, and broken glassware that are contaminated with biological material should be placed in a plastic puncture-resistant container (needlebox) and/or autoclave before disposal
- ✓ Plastic pipette tips and serological pipette tips used to process human body fluids or cultures of infectious agents, should be placed in a puncture-resistant “pipette” box with the biohazard symbol and autoclaved before disposal.
- ✓ Non-infectious pipettes should also be placed in a puncture-resistant container before disposal; however, it is not necessary to autoclave.
- ✓ Microbiological/Molecular Waste —Includes cultures and stocks of etiologic agents and recombinant DNA/transgenics. Solid waste should be placed in an autoclavable bag and autoclaved before disposal.

- ✓ Liquid biological waste (no hazardous chemicals) can be autoclaved or chemically treated (i.e. bleached) before disposal down the drain. Do not mix bleach with incompatible chemicals.
- ✓ Specimens of human blood/body fluids and tissue cultures can be placed in an autoclavable bag that has the biohazard symbol on it and autoclaved before disposal.
- ✓ Tissue Culture Wastes (Animal and Human) —All solid waste should be autoclaved before disposal. Liquid waste can be chemically disinfected (bleach) before disposal down the drain. The waste should not contain other chemicals that are incompatible with bleach or other disinfectants used.
- ✓ Anatomical/Pathological Waste —Organs, limbs, animal carcasses etc., which must be incinerated (Not Autoclaved!) for proper treatment
- ✓ Non-contaminated glass should be discarded in a bag-lined heavy-duty cardboard box labeled as "broken glass"
- ✓ Solid Disposal Supply Wastes —Disposable gloves, gauze, paper wrappings, parafilm, etc., that are minimally contaminated. Decontamination is not required before disposal; should be placed in leakproof containers (i.e., a sturdy, plastic bag).
- ✓ Shifting lab require decontamination of new place from all chemicals, biological materials, radiological materials and any other hazardous materials.
- ✓ Do not block hallways, doorways, or emergency equipment while packing or unpacking.

Source reference:

- Laboratory safety manual, NOVEMBER 2019/EDITION

Environmental Health and Safety Department, University of Washington

www.ehs.washington.edu

- Laboratory safety manual , Division of Environmental Health and Safety ,University of Florida

- Safety Manual, Duke Laboratory