Online Chemical Inventory Management System Policy & Procedure

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Date			

PROCEDURE #: UOS/CLD/SS/13

TITLE: **Online Chemical Inventory Management System Policy & Procedure**

PURPOSE: To describe the policy and procedure for Management of chemicals Inventory for all labs fall under jurisdiction of Central labs Directorate, University of Sharjah.

SCOPE: This procedure applies to all labs comes under Central Labs Directorate, University of Sharjah.

REFERENCE:

- OSHAD-SF, Ver-3; May 2017; Clause-5.2 (Chemical Hazards)
- Other applicable policies and procedure of Central Laboratories Directorate
- ISO 14001:2015, Clause: 8.1 (Operational Planning and Control)
- ISO 45001:2018, Clause: 6.1 (Actions to address risks and opportunities), Clause: 8.1 (Operational planning and control), Clause: 8.2 (Emergency preparedness and response)
- Central Labs Chemical Hygiene Plan 2019.
- Central Labs Lab Safety Manual 2020.

ABBREVIATION:

CLD – Central Laboratories Directorate

DCLD - Director Central Laboratories Directorate

DASS - Dean of Academic Support Services

LSO: Lab Safety Officer

LS- Lab Staff: (Lab Supervisors, Lab Officers, Lab Engineers, Clinical Tutors, Lab Technicians and Research Assistant)

LFM- Labs Faculty Member (Professor, Associate Professor, Assistant Professor, Lecturer and Researchers)

FMPD- Facilities Management & Planning Department
PI- Principle Investigator (LS or LFM)
GU- General User (LS or LFM)
TST- Technical Support Team
CIMS- **Chemical Inventory Management System**

Chemical Inventory Management System Policy

Lab Staff and Labs Faculty Member who use or store chemicals at University of Sharjah, are required to maintain an accurate and update chemical inventory for their laboratories regularly through the Central Labs Chemical Inventory Management System (LabcliQ) , in order to enhance labs safety, efficiently utilize the available chemicals, comply with the Local Regulations and provide critical information to responders during an emergency.

RESPONSIBILITY		ACTION
	1.0	**Online Chemical Inventory Management System**
	1.1	The Chemical Inventory Management System (LabcliQ) is a cloud-based software used to manage, identify, track and maintain chemicals in all locations at the University of Sharjah. **Note:** 1. You can access the Chemical Inventory Management System from the Central Labs portal link below: https://myuos.sharjah.ac.ae/en/Pages/CL.aspx 2. You can read the User Guide for CIMS from the Central Labs Safety portal link below: https://myuos.sharjah.ac.ae/en/Pages/CL_Safety.aspx The user guide includes: • Viewing Chemical Inventory • Searching and Filtering the Inventory • How to Add/Edit/Dispose Chemicals • Replacing and Transferring Chemicals • Exporting your Inventory
	2.0	**Add/Edit/Dispose Chemicals on CIMS**
LS, LFM	2.1	All teaching and research chemicals brought onto University of Sharjah must be entered into the Chemical Inventory Management System (LabcliQ) upon initial receipt.
LS, LFM	2.2	Ultimately responsible for ensuring that chemical containers under their control have been updated on the CIMS after any new changes on the container (dispose, transfer, replace, etc.).
LS, LFM	2.3	The inventory must include a full chemical name, CAS number, amount of the chemical with suitable units of measurement, physical state, product number, Lot No., owner, and room number, and Additionally, the expiration date must be added if it is available on the chemical.
LS, LFM	2.4	Chemical owner must dispose chemical container once it consumed completely and keep chemical inventory updated.

LS, LFM	2.5	Don't receive chemicals which are near to expire, unless you are sure to consume chemical before expiry, to avoid storing expired chemical in labs/storerooms.
	3.0	**Request of Transfer/Borrow Chemical from Another Owner (within department and outside department)**
LS, LFM	3.1	If you need a small quantity of chemical or complete chemical container from another lab within department or outside department from different chemical owner, then send require chemical container details to Central Lab Technical Support Team by email. You can export the details of the required chemical in excel format and send it by email to TST **Note:** No other LS and LFM can take your chemicals without your prior approval. Central lab technical support team will first take approval from chemical owner. If he/she agree to give the chemicals to the requester, then the request will be approved.
	4.0	**User Access Controls**
LSO	4.1	**Administrator privileges:** • Have full access and control to the entire database. • Can do all changes or necessary amendments (if require). • Adding new users to the CIMS • Ensures the system is working fine • Support lab staff or LFM in case of any problem encounter. • Monitoring the CIMS and report any nonconformity to Director of Central Labs.
LS, LFM who own chemicals	4.2	**Principal Investigator Privileges:** • Adding new chemicals. • Editing his/her own chemicals. • Disposing his/her own chemicals. • Replace existing chemicals with new ones. • Transfer chemical to another owner. • Transfer chemical to another location/lab under his/her name. • View only the entire UoS Chemical Inventory without editing/disposing/replacing/transferring the other owners' chemicals • Can give access to lab employees who are working for his/her lab by sending an official request to system administrators (LSO).
LS, LFM who don't own chemicals	4.3	**General User Privileges:** • View only the entire UoS Chemical Inventory without editing the other owners' chemicals

CL Technical Support Team	4.4	CL Technical Support team will have access as a general user account to: • View only the entire UoS Chemical Inventory • Verify the chemical inventory details for each chemicals requisition, prior to send it to procurement department. • In case of purchase request of small amount of chemical, they can borrow this amount from the chemical owners with prior approval from his/her end. • Communicate with chemical owners and get approval to borrow or transfer chemicals.
	5.0	**Monitoring and Control**
LS, LFM	5.1	Ensure your chemical inventory are updated after any changes.
LS, LFM	5.2	Verify and update the chemical inventory against the physical stock annually, recommended before starting your summer vacation (by end of June).
LSO	5.3	Report any noncompliance to DCLD, and takes appropriate action as deemed necessary.
	6.0	**Records**
CLD	6.1	• Inventory database is available online all the time

7.0 REVISION HISTORY

Revision	Date	Description	Prepared By	Reviewed By	Approved By
00	01-11-2019	Online Chemical Inventory Management System Policy & Procedure	Director CLD	Dean Of DASS	Chancellor

INTER EMIRATES BUILDING CLEANING SERVICES

UNIVERSITY OF SHARJAH- PERIODIC CLEANING

S.NO	Cleaning Job	Daily	Weekly	Monthly	Quarterly	Yearly
1	Reception and Entrance Lobby Sweep and Mop Clean	x				
2	Damp Dust All Furniture	x				
3	Clean the toilet with Disnifectant	x				
4	Entrance Glass Cleaning	x				
5	Buff the floor with Machine	x				
6	Vacuum clean the Carpet Area	x				
7	Dust Clean vertical blinds, bookcases, Cabinets & Lockers	x				
8	Remove all Garbage in office labs, classrooms and Prayer Rooms.	x				
9	Toilet general cleaning		x			
10	Clean and all the external pillar, walls, floor and ramp		x			
11	Wash and buff all the floor, stair & lifts		x			
12	Clean all the kitchen cabinet and refrigerators		x			
13	Entrance glass cleaning		x			
14	Villa corridors clean and wash		x			
15	waste bin sanitization		x			
16	Scrubbing and buffing classroom			x		
17	Carpet Shampooing carpet area			x		
18	Window glass cleaning			x		
19	Lobby area and corridors deep cleaning			x		
20	External glass cleaning				x	
21	Roof top cleaning				x	
22	Periodic cleaning to external glazing & facades					x
23	All the classrooms and corridors General cleaning & floor polishing					x
24	All the dorm corridors, window and room deep cleaning					x
25	Villa Cleaning	Upon Request	Upon Request	Upon Request	Upon Request	x

جامعة الشارقة
UNIVERSITY OF SHARJAH

Central Laboratories Directorate

Chemical Hygiene Plan

January 2019
CLD/SS/CHP
Revision 00

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The Central Laboratories Directorate would like to thank below staff members who helped prepare and finalize Chemical Hygiene Plan for University of Sharjah.

- Dr. Hamadeh Tarazi - Lecturer, College of Pharmacy
- Mr. Ahmed Hassanein- Sr. Safety Officer
- Mrs. Nemat Dek Al-Bab- Team Leader of Chemistry Labs Unit, College of Sciences
- Mr. Jobi Joseph- Lab Supervisor, Sharjah Institute for Medical Research

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- Eng. Mahmoud Abu Shammeh- Director of Central Labs.
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- Engr. Louay Al Maleh- Director of Facilities Management and Planning Department.
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- Mr. Ahmed Hassanein- Sr. Safety Officer, Central Laboratories Directorate
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Designation	Director, Central Laboratories Directorate	Committee members	Dean, Academic Support Services
Signature		As per approved meeting minutes no.2 for 2018-2019	
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1.0 Introduction

Laboratories are potentially dangerous places. Chemical and physical hazards are present and a lack of knowledge or a moment's inattention could lead to an injury, illness, death or property damage. To reduce the likelihood of laboratory accidents and to achieve the University of Sharjah Commitment to provide a safe laboratory environment for faculty, staff and students, the Central Labs Directorate has developed a general Chemical Hygiene Plan (CHP). The plan includes a set of safety policies and procedures that protect workers from the health and physical hazards associated with the hazardous chemicals used in the University of Sharjah Labs.

Each laboratory using hazardous chemicals is required to have a copy of the CHP readily available to all laboratory personnel. Each laboratory worker must be familiar with the contents of the CHP and the procedures for obtaining additional safety information needed to perform their duties safely. The softcopy of this plan is available on the Cl Safety Portal and the hard copies will also be located in the individual labs.

This CHP will be regularly reviewed and updated with inputs, comments, and suggestions from UOS faculty and staff. Suggestions for the improvement of this document are welcomed, please contact CLD.

1.1 Purpose

The purpose of this CHP is to define safe work practices and procedures to help ensure that faculty, staff and students are protected from the health and physical hazards associated with the handling, storage and use of hazardous chemicals in University laboratories and to comply with the University of Sharjah Internal Audit Office Requirements.

1.2 Scope and applicability

The CHP applies to all laboratories and laboratory personnel at the University of Sharjah that use, store, or handle hazardous chemicals.

This generic Chemical Hygiene Plan was written to fulfill uniform requirements applicable to most University labs. It is not intended to be all-inclusive. It cannot address specific chemical handling procedures for all chemicals but describes general protective guidelines for working with hazardous chemicals in laboratories.

Departments, individual labs or research groups engaged in work with potentially hazardous chemicals that have unusual characteristics, or not covered in this CHP, must customize the document by adding additional sections addressing the hazards and how to mitigate their risks, as appropriate.

Laboratory personnel include faculty, staff, research associates and assistants, technicians, teaching assistants, post-doctoral fellows, graduate and undergraduate students must read, understand and comply with the CHP prior to work with hazardous chemicals in laboratories.

A written record stating that each laboratory worker has reviewed the Chemical Hygiene Plan and related health and safety training shall be kept by the person in charge of the lab. See Appendix 2 for a copy of this document.

1.3 Roles and responsibilities

1.3.1 College Deans, Chairs of Departments and Director of Central Labs

1. Responsible and accountable for the environmental, health and safety performance of their colleges / departments.
2. Ensures that the Central Labs health and safety policy and procedures, and Chemical Hygiene Plan are adhered and implemented.
3. Ensures provision of adequate budget and resources for EHS management as and when needed.
4. Ensures provision of EHS information, training and supervision.
5. Shut down the lab in case of serious violations which may cause severe consequences.
6. Ensures compliance with applicable legal requirements related to labs and relevant activities.

1.3.2 Lab Staff/Lab Faculty Member

Lab Staff: (Lab Supervisors, Lab Officers, Lab Engineers, Clinical Tutors, Lab Technicians and research assistant)

Lab Faculty Member: (Professor, Associate Professor, Assistant Professor, Lecturer and Researchers)

1. Complies with the Central Labs health and safety policy and procedures, the recommended safe work practices, Central Labs safety instructions and UOS Chemical Hygiene Plan.
2. Ensures that personnel working in laboratories know and follows the guidelines and requirements contained within the Laboratory Safety Manual, policies and procedures.
3. Ensures that personnel working in laboratories are familiar with the contents and location of the lab safety manual, policies and procedures, emergency response guide and all emergency response equipment such as fire extinguisher, eyewash and emergency showers, etc.
4. Reports immediately about malfunctioning of lab equipment, including protective equipment such as fume hoods, biological safety cabinets, safety showers and fire extinguishers to the central labs directorate for immediate action.
5. Holds the primary responsibility for ensuring that all laboratory work is done safely avoiding incidents.
6. Ensures availability of proper PPE and they are in good working condition. Also ensures all laboratory personnel have received the appropriate training on the selection and use of proper PPE and they use it when working in laboratories under their supervision.
7. Plans and conducts each activity / operation / experiment with taking in considerations best safety practices and risk associated with each activity.
8. Carry out a risk assessment prior to the lab operations and if required, ensure risk control measures are in place.
9. Ensures laboratories under supervision are maintained in a clean and orderly manner, and personnel working in the lab practice good housekeeping.
10. Restricts access of visitors and children to areas under their supervision when potential health and physical hazards exist, with the exception of university approved activity e.g., tours, school visits, etc.
11. Ensures that all safety measures for unattended operations / experiments are evaluated to avoid any incidents that may happen.

12. Ensures that staff and students under supervision are provided with adequate training and information specific to the hazards found within respective laboratories on how to work safely with these hazards. Note: Hazards may include; Chemical, Biological, Radiological, Mechanical, Electrical, and other health and physical hazards.
13. Keeps updated chemical and / or Biological inventories in the lab and stores chemicals according to compatibility.
14. Ensures that Safety Data Sheets (SDS) are accessible for all chemicals and Biological in use or stored.
15. Performs monthly self-inspection for the lab(s) under control and consults with the safety staff when safety questions or concerns arise.
16. Ensures cleaning of any chemical or biological spill that may happen.
17. Ensures safe handling, storage and disposal of hazardous waste.
18. Attends health and safety training.
19. Faculty are required to provide all lab students with the proper links to all safety documents through the blackboard system and enforce them to read it.
20. Stop any activity that may cause harm to the Human life/ Assets/ Environment…etc.
21. Completes any corrective action assigned during a lab safety inspection before the due date.
22. Ensure those contractors are properly supervised during installation process to avoid any incidents.
23. Reports any incident immediately to the DCLD or LSO using "Incident Report".
24. Ensures compliance with applicable legal requirements related to labs and relevant activities.

1.3.3 Lab Team Leader

1. Complies with the Central Labs health and safety policy and procedures, the recommended safe work practices, Central Labs safety instructions and UOS Chemical Hygiene Plan.
2. Ensures that lab staff under your supervision complies with the Central Labs health and safety policy and procedures, the recommended safe work practices and Central Labs safety instructions.
3. Inspect and Monitor labs under your supervision regularly and report any violation to Chair of Department.
4. Ensures that lab staff under your supervision completes any corrective action assigned during a lab safety inspection before the due date.
5. Stop any activity that may cause harm to the Human life/ Assets/ Environment…etc. and report to Chair of Department.
6. Ensures lab staff under your supervision are attending health and safety training.
7. Ensures lab staff under your supervision are reporting the incidents immediately to DCLD or LSO
8. Ensure lab staff under your supervision are carrying out monthly self-lab safety inspection for their labs.
9. Ensures compliance with applicable legal requirements related to labs and relevant activities.

1.3.4 Laboratory Safety Committee

1. Reviews the safety measures and procedures implemented in Central Labs and suggest improvements.
2. Develops new policies and procedures regarding laboratory safety as required.
3. Ensures that local safety regulations, requirements and standards are met.
4. Reviews, develops, updates and approves manuals, procedures and emergency response plans issued by the Central Labs Directorate.
5. Reviews and approves training programs.
6. Reviews inspection reports, incident reports internal and external laboratories audit and develop corrective strategies where needed.
7. Investigates lab related incidents that may happen and report violations to the top management.

1.3.5 Central Labs Safety Officer

1. Complies with the Central Labs health and safety policy and procedures.
2. Facilitates the implementation of CLD Policies and procedures, Chemical Hygiene Plan and assist in establishing a safe work environment by collaborating with the lab supervisor, faculty and lab personnel.
3. Conducts periodic and un-announced laboratory inspections of all Central labs facilities to verify lab safety checklist and report any safety issues to the Central Labs director and chair of department.
4. Provides advice to relevant personnel on the implementation of CLD policies and procedures as and when needed.
5. Provides all appropriate and required personal protective equipment PPE to laboratory personnel based on their request.
6. Coordinates for buying safety supplies and equipment required for the central labs.
7. Manages the collection and disposal of hazardous waste.
8. Reviews laboratory incidents reports and recommends appropriate corrective actions when required.
9. Stop any activity that may cause harm to the Human life/ Assets/ Environment…etc, and report to DCLD.
10. Ensures compliance with applicable legal requirements related to labs and relevant activities.

1.3.6 Central Labs Maintenance Section

1. Ensure that all lab equipment/machines are properly installed and placed safely according to manufacturer recommendations, and maintain the relevant records.
2. Ensures lab staff are appropriately trained on newly installed equipment and all relevant safety instructions and maintain the training records.
3. Develop Preventive Maintenance Plan for emergency and safety equipment such as safety shower and eyewash station, fume hoods, Biological safety cabinets…etc. and other lab equipment/machines which required regular maintenance and perform the maintenance accordingly.
4. Check regularly the LPG system and compressed gas cylinders for any issues and take corrective actions accordingly.
5. Respond immediately to any lab equipment maintenance request.

6. Ensure those contractors are properly supervised during installation process to avoid any incidents.

1.3.7 Students

1. Complies with the Central Labs health and safety policy and procedures, the recommended safe work practices, Central Labs safety instructions and UOS Chemical Hygiene Plan.
2. Wears the appropriate personal protective equipment when present in the lab and when conducting work with hazardous materials or operations.
3. Familiarizes with the location of emergency equipment and emergency response plans.
4. Never work alone in the lab, always asks for proper supervision.
5. In case material or equipment is unfamiliar and not trained with it, then Informs the supervisor before working with such material and equipment.
6. Report any unsafe conditions or incidents to the lab staff immediately
7. Ensures compliance with applicable legal requirements related to labs and relevant activities.

2.0 Chemical Management

2.1 Chemical Procurement and Receiving

1. Only the minimum amount of the chemical needed to perform the planned work should be ordered. Preferably for one academic year.
2. Where possible, substitute highly hazardous chemicals with less hazardous chemicals.
3. Only containers with proper labels identifying the chemical and its hazard should be accepted.
4. Shipments with breakage or leakage should be refused.
5. Proper protective equipment and handling and storage procedures should be in place before receiving a shipment.
6. Purchases of high-risk chemicals should be reviewed and approved by the Chair of the Department, with the assistance of Central Labs Safety Section if necessary.
7. Chemical shipments should be dated upon receipt and the inventory should be updated.

2.2 Chemical Storage

1. Chemicals should be separated and stored according to hazard category and compatibility (refer to <u>Appendix 6</u>). Always consult SDS and label information for storage requirements.
2. Maintain existing labels on incoming containers of chemicals and other materials.
3. Peroxide formers should be dated upon receipt, again dated upon opening, and stored away from heat and light with tight-fitting, nonmetal lids.
4. Label all containers of hazardous chemicals (including transfer vessels, beakers, flasks, and process equipment) with the chemical name and hazard warnings.
5. Open shelves used for chemical storage should be secured to the wall.
6. Secondary containment (bin, tray, bucket, basin) should be used for liquids.
7. Keep incompatibles separate during transport, storage, use, and disposal. Consult the SDS
8. Oxidizers and flammables should be stored separately to prevent contact in the event of an accident.
9. Chemicals should not be stored in the chemical fume hood, on the floor, in areas of egress, on the benchtop (except for small amounts of working solutions), near heat sources, or in direct sunlight.
10. Laboratory-grade, flammable-rated refrigerators and freezers should be used to store sealed chemical containers of flammable liquids that require cool storage.
11. Highly hazardous chemicals should be stored in a well-ventilated and secure area designated for that purpose.
12. Storage of more than 10 gallons of flammable and combustible liquids (with a flash point less than 100^{o} F~37.7^{o}C) shall be in an approved flammable liquid storage cabinet.
13. Flammable chemicals should be stored in a spark-free environment and in approved flammable-liquid containers and storage cabinets. Grounding and bonding should be used to prevent static charge buildups when dispensing solvents.
14. Chemical storage and handling rooms should be controlled-access areas. They should have proper ventilation, appropriate signage, and fire suppression systems.

2.3 Chemical Handling

1. A risk assessment should be conducted prior to beginning work with any hazardous chemical for the first time. (see <u>Appendix 3</u>)
2. Read all SDS and label information before using a chemical for the first time, or if it has been awhile since using the chemical.
3. Lab Staff should ensure that proper engineering controls (ventilation) and PPE are in place.
4. Use adequate ventilation (such as a fume hood) when transferring even a small amount of a particularly hazardous chemical.

5. Transfer flammable liquids from 5 gallon containers (or less) to smaller containers only in a laboratory fume hood.

2.4 Chemical Inventory

Prudent management of chemicals in any laboratory is greatly facilitated by keeping an accurate, up-to-date chemical inventory.

1. A current copy of the inventory must be kept in the laboratory. Chemical inventory form is available on the Central Labs Safety Portal.
2. Chemicals that are no longer needed or are waste should be disposed through waste disposal contractor (Wekaya) or given to another lab/department to use them.
3. Compressed gases need to be included in the chemical inventory.

2.5 Chemicals Transporting

1. Uses bottle carriers or carts with secondary containment when transporting chemicals outside of the laboratory or between stores and laboratories.
   a) The carrier or cart will protect glass container from breakage during transportation through hallways.
   b) The carriers and carts are available in Central Labs Store.
2. Makes sure that incompatible chemicals are not transported at the same time.
3. Wear appropriate personal protective equipment (PPE) while transporting chemicals.
4. While transporting chemicals between W12 - M12 buildings, follow the new Central Labs paved pathways.
5. Use unoccupied passenger elevator for transporting chemicals between floors.
6. Never transport chemicals in your personal car as it may cause serious consequences. Always call Central Labs Safety Section for assistance.

2.6 Chemical Waste Management

Hazardous waste is generally defined as waste that is dangerous or potentially harmful to human health or the environment. Every effort should be made to dispose of hazardous waste in a proper, safe, and efficient manner. It is the responsibility of the individual creating the waste to properly identify and manage waste chemicals within the lab prior to pick-up by the waste disposal company "Wekaya". No chemical waste should be poured down the drain or discarded in the trash unless it is certain that doing so does not violate hazardous waste regulations.

Local and international Hazardous waste regulations and laws:

1. Decision No.5/2011 of Executive Council of the Emirate of Sharjah on healthcare waste management.
2. UAE Federal Law No. 24 of 1999 concerning protection and development of Environment.
3. UAE Cabinet Resolution (Ministerial Order) No. 37 of 2001, "Handling of Hazardous Substances, Hazardous Wastes and Medical Wastes".
4. MOH administrative decision No.79, 2009 on Medical Waste Management
5. Recommendations of World Health Organization (WHO), "Safe Management of Waste from Health-Care Activities
6. Environmental Protection Agency (EPA)

Violations and Fines

According to Decision No. 5/2011 of Executive Council of the Emirate of Sharjah on healthcare management there is a fine of 150,000 AED in case of the below violations:

1. Dumping of Health Care Waste (HCW) in bins which are not assigned for.
2. Dumping into land.

3. Discharging into the sea.

2.6.1 Waste Identification and Labeling

1. All chemical constituents in a hazardous waste container must be identified by full chemical names (i.e., do not use chemical formulas or abbreviations). Additionally, consult SDSs (specifically Section 2, "Hazard Identification" and Section 13, "Disposal Considerations") to obtain information about hazardous constituents and characteristics.
2. Mixed waste containers must be labeled from the moment waste is added to the container. This will prevent accidental mixing of incompatible chemicals. You can print the CL Hazardous Waste Label and pasted on the container.
3. The label must be completed prior to disposal by Wekaya.
4. Empty containers do not have to be managed as hazardous waste. An exception for this is that empty containers that previously held acutely/extremely hazardous chemicals are considered hazardous waste and must be given to Wekaya for disposal.
5. Sharps waste contaminated with hazardous chemicals must be placed into puncture resistant containers (e.g., sharps container, plastic or metal container with lid) and properly labeled.
6. Batteries such as nickel-cadmium, mercury, silver, lithium, nickel-metal hydride, lead-acid and any other rechargeable batteries are considered hazardous waste but alkaline batteries are not considered hazardous waste and can be discarded in the trash.

Hazardous Waste Label			
Building-Lab No.			
Lab Staff Name			
	Contents	Hazard	Volume (ml/L)
1			
2			
3			
4			
5			
Comments:			

2.6.2 Waste Storage Requirements

The following procedures must be followed in order to have hazardous waste safely stored prior to collection by Wekaya:

1. Keep all hazardous materials in appropriate closed containers with airtight lids.
2. Containers must be in good condition and compatible with the waste they contain (no corrosive waste in metal containers).
3. Containers must be kept closed at all times except when adding waste.
4. Containers must be labelled with full chemical names, hazards and exact content.
5. Containers should be segregated by chemical compatibility during storage (e.g., acids away from bases, secondary containment can be used as a means of segregation).
6. Do not mix incompatible chemicals in the same container. (e.g., oxidizers with flammables, acids with bases)
7. Do not store hazardous waste in the fume hood.
8. Do not mix hazardous materials with non-hazardous materials. It greatly increases waste disposal costs.
9. Containers that continually generate hazardous wastes (e.g., HPLC wastes) must be placed in secondary containment, and all tubes and hoses must be closed as much as possible to minimize potential release.
10. Containers must be stored at or near the point of generation (wastes should remain in the same room they were generated in).

2.6.3 Waste Disposal Procedures

To have your hazardous waste picked up by "Wekaya", you must follow the following procedures:

1. Fill the waste list form (Appendix 5) and send it through email as a soft copy with SDSs for all materials to the Medical waste officer in your facility.
2. Follow packaging requirements for Wekaya (Appendix 9)
3. Bring the waste to the collection point as instructed by the medical waste officer.
4. When transporting chemical waste, you must use chemical transport cart or leak proof trolley which is available at Central Labs store.
5. Ensure "Hazardous Waste" label with full chemical names, and volume are clearly displayed on each container.
6. The outside of the containers must be clean and free of chemical contamination.
7. The company will NOT accept unknown waste chemicals or hazardous wastes that have chemical abbreviations or symbols.
8. Medical waste officer will arrange with the company for waste collection from our facilities

Remember

- Do not dispose of chemicals by pouring them down the drain or placing them in the trash.
- Do not use fume hoods to evaporate hazardous chemicals.

2.6.4 Waste Minimization

Waste minimization is any action that reduces the amount of hazardous wastes before they are shipped off-site for disposal and it is very important to protect the environment and also to reduce the disposal costs.

Guidelines for Waste Reduction

1. Order only and store the amount of material needed for the project or experiment. Hazardous waste is often a result of outdated and/or unused chemicals.
2. Substitute hazardous materials with less toxic or non-hazardous compounds, such as using spirit, bi-metal, or digital thermometers instead of mercury thermometers.
3. Using micro or semi-micro techniques in the teaching and research laboratories whenever it is possible.
4. Maintain current chemical inventories and review inventories before purchasing additional chemicals.
5. Before disposing of unwanted, unopened, uncontaminated chemicals check with others in your department or other departments who may be able to use them.
6. Recycling: distill and reuse solvents if possible.

3.0 Hazardous Chemicals Identification and classification

Chemical classification systems are designed to communicate hazards. The three most widely used classification systems are the American Occupational Safety and Health Administration (OSHA) Globally Harmonized System for Classifying and Labeling Chemicals, the National Fire Protection Association (NFPA) system of classifying the severity of hazards, and the Department of Transportation (DOT) hazard classes. These classification systems are used by chemical manufacturers when creating safety data sheets and chemical labels, therefore it is important that lab employees understand the basic elements of each classification system.

3.1.1 Globally Harmonized System for Classifying Chemicals (GHS)

The Globally Harmonized System (GHS) is a world-wide system adopted by OSHA for standardizing and harmonizing the classification and labeling of chemicals. The objectives of the GHS are to:

- Define health, physical, and environmental hazards of chemicals;
- Create classification processes that use available data on chemicals for comparison with the defined hazard criteria (numerical hazard classification is based on a 1 – 5 scale, 1 being the most hazardous and 5 being the least hazardous); and
- Communicate hazard information, as well as protective measures, on labels and Safety Data Sheet (SDS), formerly known as Material Safety Data Sheets (MSDS).

3.1.1.1 Safety Data Sheets (SDSs)

The SDS provides comprehensive information that is essential for the safe handling of hazardous chemicals. Laboratory personnel should use the SDS as a resource to obtain information about hazards and safety precautions. SDSs cannot provide information for hazards in all circumstances. However, the SDS information enables the employees to develop safety control measures such as Standard Operating Procedures (SOPs). The SDS contains 16 headings which are illustrated as following:

1. **Section 1, Identification** includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.
2. **Section 2, Hazard(s) identification** includes all hazards regarding the chemical; required label elements.
3. **Section 3, Composition/information on ingredients** includes information on chemical ingredients; trade secret claims.
4. **Section 4, First-aid measures** includes important symptoms/ effects, acute, delayed; required treatment.
5. **Section 5, Fire-fighting measures** lists suitable extinguishing techniques, equipment; chemical hazards from fire.
6. **Section 6, Accidental release measures** lists emergency procedures; protective equipment; proper methods of containment and cleanup.
7. **Section 7, Handling and storage** lists precautions for safe handling and storage, including incompatibilities.
8. **Section 8, Exposure controls/personal protection** lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).
9. **Section 9, Physical and chemical properties** lists the chemical's characteristics.
10. **Section 10, Stability and reactivity** lists chemical stability and possibility of hazardous reactions.

11. **Section 11, Toxicological information** includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
12. **Section 12, Ecological information**
13. **Section 13, Disposal considerations**
14. **Section 14, Transport information**
15. **Section 15, Regulatory information**
16. **Section 16, Other information,** includes the date of preparation or last revision.

3.1.1.2 Chemical Labeling

The GHS standardized label elements, which are not subject to variation and must appear on the chemical label, contain the following elements:

- Symbols (hazard pictograms) are used to convey health, physical and environmental hazard information, assigned to a GHS hazard class and category;
- Signal Words such as "Danger" (for more severe hazards) or "Warning" (for less severe hazards), are used to emphasize hazards and indicate the relative level of severity of the hazard assigned to a GHS hazard class and category;
- Hazard statements (e.g., "Danger! Extremely Flammable Liquid and Vapor") are standard phrases assigned to a hazard class and category that describe the nature of the hazard; and
- Precautionary statements are recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to the hazardous chemical.

The GHS also standardizes the hazard pictograms that are to be used on all hazard labels and SDSs. There are 9 pictograms that represent several defined hazards, and include the harmonized hazard symbols which are intended to convey specific information about each hazard. The following table illustrates these GHS hazard pictograms.

		
Carcinogen, Respiratory Sensitizer, Reproductive Toxicity, Target Organ Toxicity, Mutagenicity	**Flammable, Pyrophoric, Self- Heating, Emits Flammable Gas, Organic Peroxide**	**Irritant, Dermal Sensitizer, Acute Toxicity (harmful), Narcotic Effects**
		
Gas Under Pressure	**Corrosive**	**Explosive, Organic Peroxide, Self-Reactive**

		
Oxidizer	**Environmental Toxicity**	**Acute Toxicity (Severe)**

GHS Hazard Pictograms

Since most chemicals stored in the laboratory have been purchased from a chemical manufacturer, the GHS labeling and pictogram requirements are very relevant and must be understood by laboratory employees. The below template illustrates the GHS label format showing the required elements.

ACETONE

PRODUCT IDENTIFIER

Code:
Product Name:

SUPPLIER IDENTIFICATION

Company Name:
Address:
Phone Number:

PRECAUTIONARY STATEMENTS

Keep away from heat, sparks, open flames, hot surfaces – No smoking.
Avoid breathing dust, fumes, gas, mist, vapors, and spray.
Repeated exposure may cause skin dryness and cracking.
In Case of Fire: Use water spray, alcohol-resistant foam, dry chemical, or carbon dioxide.
First Aid: Move out of dangerous area. Consult a physician. If inhaled, move person to fresh air. If not breathing, give artificial respiration. In case of skin contact, wash with soap and plenty of water. In case of eye contact, rinse thoroughly with plenty of water for at least 15 minutes. If swallowed, do not induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water, consult a physician.

HAZARD PICTOGRAMS

SIGNAL WORD

Danger

HAZARD STATEMENT

Highly flammable liquid and vapor. Causes mild skin irritation.
Causes serious eye irritation.
May cause drowsiness or dizziness.

GHS Label Format

As mentioned earlier, one of the objectives of GHS was to create a quantitative hazard classification system (numerical hazard classification is based on a 1 – 5 scale, 1 being the most hazardous and 5 being the least hazardous) based on physical characteristics such as flash point, boiling point, lethal dose of 50% of a population, reactivity, etc. the below table illustrates how the numerical hazard classification works for flammable liquids.

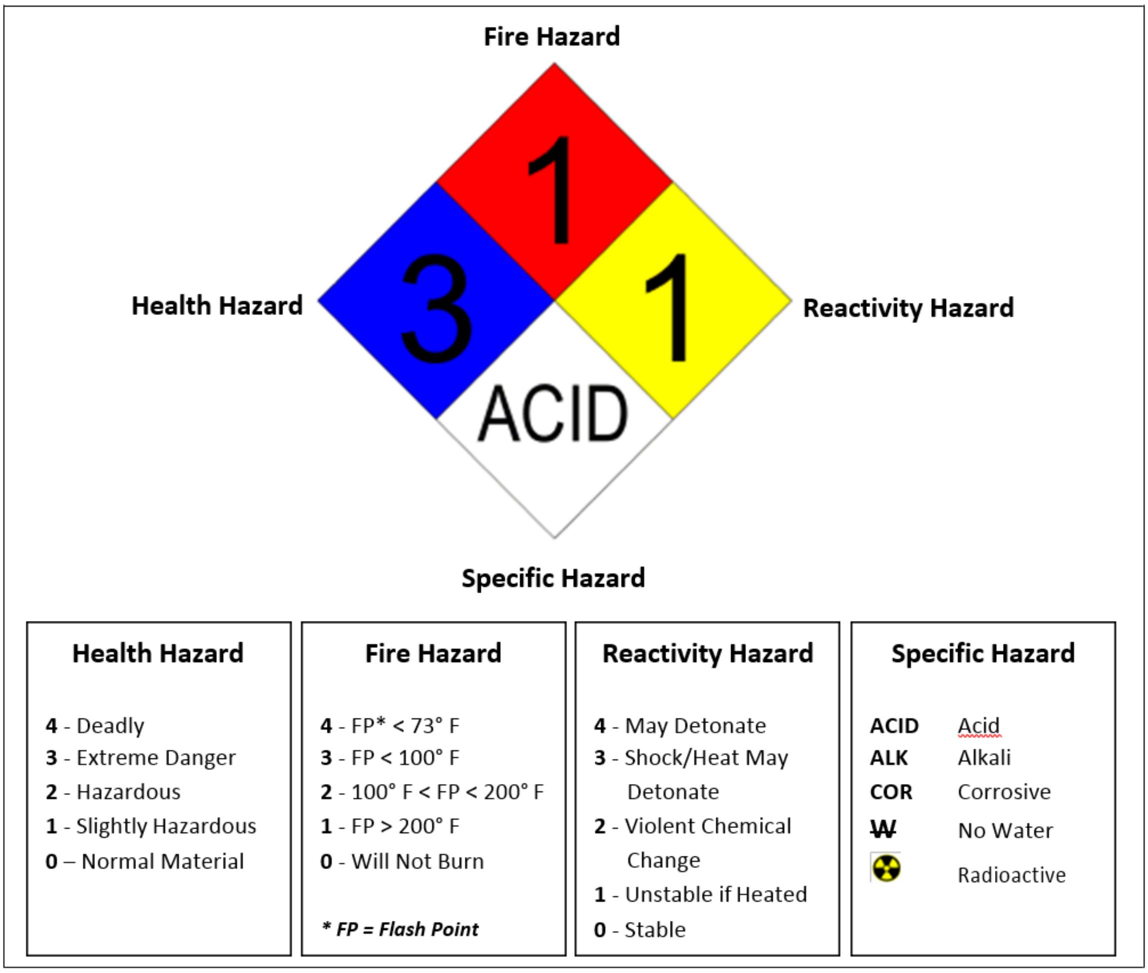
Category	Criteria	Pictogram	Signal Word	Hazard Statement
1	Flash point < 23 °C Boiling point ≤ 35 °C		Danger	Extremely flammable liquid and vapor
2	Flash point < 23 °C Boiling point > 35 °C		Danger	Highly flammable liquid and vapor

3	Flash point ≥ 23 °C and < 60 °C		Warning	Flammable liquid and vapor
4	Flash point ≥ 60 °C and ≤ 93 °C		Warning	Combustible liquid
5	There is no Category 5 for flammable liquids			

GHS Hazard Classification System for Flammable Liquids

3.1.2 National Fire Protection Association Rating System

The NFPA system uses a diamond-shaped diagram of symbols and numbers to indicate the degree of hazard associated with a particular chemical. This system was created to easily and quickly communicate hazards to first responders in the event of an emergency situation. These diamond-shaped symbols are placed on chemical containers to identify the degree of hazard associated with the specific chemical or chemical mixture. The NFPA system is a common way to identify chemical hazards and should be understood by laboratory employees. The NFPA 704 numerical rating system is based on a 0 – 4 system; 0 meaning no hazard and 4 meaning the most hazardous (note: this in contrast to the GHS system of 1 –5 where 1 is the most hazardous and 5 is the least hazardous). The below figure illustrates the NFPA hazard rating system and identifies both the hazard categories and hazard rating system.



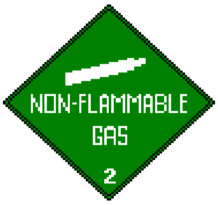
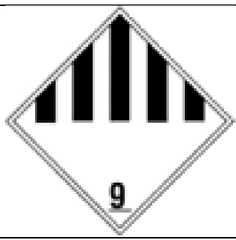
NFPA Hazard Rating System

3.1.3 Department of Transportation Hazard Classes

The DOT regulates the transportation of all hazardous materials, and defines a hazardous material as any substance that has been determined to be capable of posing an unreasonable risk to health, safety, or property when transported in commerce. There are several methods that can be employed to determine whether a chemical is hazardous for transport, a few of which included:

- Reviewing the DOT Hazardous Materials Table
- Reviewing the SDS, specifically Section 2: Hazardous Identification and Section 14: Transport Considerations, for the chemical being shipped.
- Reviewing the chemical label and looking for hazard information.
- Understanding the chemical and physical properties of the chemical.

All hazardous chemicals must be properly labeled by the chemical manufacturer or distributor before transportation occurs. Chemical containers stored in laboratories are not required to be labeled per DOT standards; however, the DOT 9 hazard classes are often seen on chemical containers and are discussed in Section 14 of GHS-formatted SDSs. The DOT 9 hazard classes are illustrated below. It should be noted that the below table only lists the primary hazard classes.

		
DOT Class 1 Explosives	**DOT Class 2 Compressed Gases**	**DOT Class 3 Flammable Liquids**
		
DOT Class 4 Flammable Solids	**DOT Class 5 Oxidizers**	**DOT Class 6 Poisons**
		
DOT Class 7 Radioactive Materials	**DOT Class 8 Corrosives**	**DOT Class 9 Miscellaneous**

DOT Hazard Classes

4.0 Hazardous Chemicals Classes

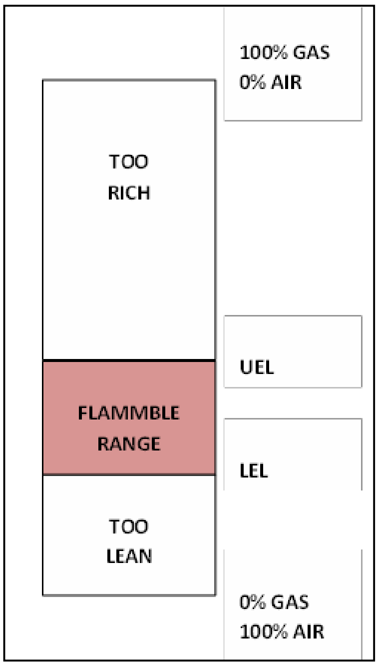
Chemicals can be divided into several different hazard classes. The hazard class provides information to help determine how a chemical can be safely stored and handled. Each chemical container, whether supplied by a chemical manufacturer or produced in the laboratory, must have a label that clearly identifies the chemical constituents. In addition to a specific chemical label, more comprehensive hazard information can be found by referencing the SDS for that chemical. The OSHA Laboratory Standard defines a hazardous chemical as any element, chemical compound, or mixture of elements and/or compounds which is a physical or health hazard. This definition of a hazardous chemical and the GHS primary classes of chemicals are briefly discussed below.

4.1 Physical Hazards

A chemical is a physical hazard if there is scientifically valid evidence that it is flammable, combustible, water reactive, explosive, organic peroxide, oxidizer, pyrophoric, self-heating, self-reactive, or a compressed gas. Each physical hazard is briefly defined below.

4.1.1 Flammable Liquids

Flammable hazards are materials which under standard conditions can generate sufficient vapor to cause a fire in the presence of an ignition source. Flammable liquids (e.g., hexane, ethyl acetate, and xylene) are more hazardous at elevated temperatures due to more rapid vaporization. The following definitions are important to understand when evaluating the hazards of flammable liquids:



- **Flammable liquid** is a liquid having a flash point at or below 93 °C (200 °F).
- **Flash point** is the minimum temperature at which the application of an ignition source causes the vapors of a liquid to ignite under specified test conditions.
- **Boiling point** is the temperature at which the vapor pressure of a liquid equals the atmospheric pressure and the liquid changes into a vapor.
- **Auto ignition temperature** is the minimum temperature at which self-sustained combustion will occur in the absence of an ignition source.
- **Lower explosive limit (LEL)** is the lowest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat).
- **Upper explosive limit (UEL)** is the highest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat).

Some organic solvents (e.g., diethyl ether) have the potential to form potentially shock- sensitive organic peroxides. See **Appendix 10** for additional information regarding peroxide forming chemicals.

Flammable Liquids Storage

The following guidelines for storing flammable liquids must be followed in all laboratories:

1. Stored away from ignition sources such as open flames, smoking materials, hot surfaces,

sparks from welding or cutting, operation of electrical equipment, and static electricity.

2. Flammable and combustible liquids should be stored in flammable storage cabinets whenever possible. No more than 10 gallons of flammable liquid is permitted to be stored outside of a flammable storage cabinet unless it is stored in a flammable safety can equipped with a spring-loaded lid and an internal screen as shown.

3. Domestic refrigerators or freezers must never be used to store flammable liquids. Flammable liquids can only be stored in refrigerators or freezers that are designed for flammable materials (Note: most refrigerators and freezers are not intended for flammable storage).
4. Flammable liquids must be stored in well-ventilated areas free from ignition sources.
5. Some organic solvents (e.g., diethyl ether, tetrahydrofuran) have a shelf-life and can form organic peroxides over time while in storage. These “peroxide formers” must be dated when received from the chemical manufacturer and disposed of once expired. If any time-sensitive chemicals are found to be past the manufacturer’s expiration date, they must be submitted to Central Labs Safety Section for hazardous waste disposal immediately. See Appendix 10 for a list of commonly found organic solvents that potentially form organic peroxides.

4.1.2 Flammable Solids

A flammable solid is a solid which is readily combustible, or may cause or contribute to a fire through friction. Readily combustible solids are powdered, granular, or pasty substances which are dangerous if they can be easily ignited by brief contact with an ignition source. Flammable solids are more hazardous when widely dispersed in a confined space (e.g., finely divided metal powders).

4.1.3 Pyrophoric, Self-Heating, and Self-Reactive Materials

Pyrophoric material (also called “spontaneously combustible”) is a liquid or solid that even in small quantities and without an external ignition source can ignite after coming in contact with the air.

Self-heating material is a solid or liquid, other than a pyrophoric substance, which, by reaction with air and without energy supply, is liable to self-heat. This endpoint differs from a pyrophoric substance in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days).

Self-reactive material is a thermally unstable liquid or solid liable to undergo a strongly exothermic thermal decomposition even without participation of oxygen (air).

4.1.4 Water-Reactive Materials

A water-reactive material is a liquid or solid that reacts violently with water to produce a flammable or toxic gas, or other hazardous conditions. Alkali metals (e.g., sodium, potassium) and metal hydrides (e.g., calcium hydride) are common water-reactive materials found in laboratories.

Reactive Materials Storage

The following guidelines for storing reactive materials must be followed in all laboratories:

1. The amount of reactive materials stored in the lab must be kept to a minimum. Any expired or unnecessary reactive materials must be properly disposed of as hazardous

waste.
2. All reactive materials must be clearly labeled with the original manufacturer's label, which should have the chemical name, hazard labels, and pictograms. The label should not be defaced in any way.
3. All reactive materials should be placed into secondary containment as a best management practice.
4. Suitable storage locations for reactive materials include inert gas-filled desiccators or glove boxes, flammable storage cabinets that do not contain aqueous or other incompatible chemicals, or intrinsically safe refrigerators or freezers that also do not contain aqueous or other incompatible chemicals. If possible, store all reactive chemicals in a small flammable cabinet (such as a cabinet underneath a fume hood) dedicated only for reactives. Signs should be posted to indicate their presence and unique hazards.
5. Many reactive materials are water and/or air reactive and can spontaneously ignite on contact with air and/or water. Therefore, reactives must be handled under an inert atmosphere and in such a way that rigorously excludes air and moisture.
6. If reactive materials are received in a specially designed shipping, storage, or dispensing container (such as the Aldrich Sure-Seal packaging system), ensure that the integrity of that container is maintained. Ensure that sufficient protective solvent, oil, kerosene, or inert gas remains in the container while reactive materials are stored.

4.1.5 Oxidizers

An oxidizing solid/liquid is a solid/liquid which, while in itself is not necessarily combustible, may generally by yielding oxygen, cause or contribute to the combustion of other material. Hydrogen peroxide, nitric acid, and nitrate solutions are examples of oxidizing liquids commonly found in a laboratory. Sodium nitrate, Sodium perchlorate, and Potassium permanganate are examples of oxidizing solids commonly found in a laboratory.

4.1.6 Organic Peroxides

An organic peroxide is an organic liquid or solid which contains the bivalent -O-O- structure and may be considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. The term also includes organic peroxide formulations (mixtures). Such substances and mixtures may:

- Be liable to explosive decomposition;
- Burn rapidly;
- Be sensitive to impact or friction; or
- React dangerously with other substances

Oxidizers and Organic Peroxide Storage

The following guidelines for storing oxidizers and organic peroxides must be followed in all laboratories:

1. Oxidizers (e.g., hydrogen peroxide, sodium nitrate) and organic peroxides (e.g., methyl ethyl ketone peroxide, benzoyl peroxide) must be stored in a cool, dry location and kept away from combustible materials such as wood, pressboard, paper, and organic chemicals (e.g., organic solvents and organic acids).
2. If possible, store all strong oxidizing agents in a chemical cabinet dedicated only for oxidizers.
3. The amount of oxidizers and organic peroxides stored in the lab should be kept at a

minimum.

4. Peroxide forming solvents should be sealed tightly and stored away from light and heat.
5. All material must be clearly labeled; the original manufacturer's label with the chemical name, hazard labels, and pictograms should not be defaced or covered.

4.1.7 Explosives

An explosive substance (or mixture) is a solid or liquid substance (or mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed that can cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gases. A pyrotechnic substance (or mixture) is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative, self-sustaining, exothermic chemical reactions. An explosive compound that is sometimes found in a laboratory setting is picric acid (2,4,6-trinitrophenol).

4.1.8 Gases under Pressure

The Globally Harmonized System (GHS) of classification and labeling of chemicals defines "Gases under Pressure" as gases that are contained in a receptacle at a pressure not less than 280 kPA at 20 °C or as a refrigerated liquid.

The GHS has four groups for gases under pressure:

- **Compressed gas** is a gas which when packaged under pressure is entirely gaseous at -50 °C; including all gases with a critical temperature ≤ -50 °C.

  The critical temperature is the temperature above which a pure gas cannot be liquefied, regardless of the degree of compression.
- **Liquefied gas** is a gas which when packaged under pressure is partially liquid at temperatures above -50 °C.
- **Refrigerated liquefied gas** is a gas which when packaged is made partially liquid because of its low temperature.
- **Dissolved gas** is a gas which when packaged under pressure is dissolved in a liquid phase solvent.

All compressed gases are hazardous and present both a physical and a health hazard due to the fact they are stored in compressed cylinders, which can explode and act as a projectile if ruptured. Compressed gases also carry the hazards of the chemicals they contain such as asphyxiation (carbon dioxide), toxicity (nitric oxide), flammable (propane), and corrosive (hydrogen chloride).

Remember

- Cylinders that are knocked over or dropped can be very dangerous. If a valve is knocked off, the cylinder can become a lethal projectile.
- Accidental releases may result in an oxygen-depleted atmosphere or adverse health effects.

The following guidelines will help ensure safe handling, use, and storage of compressed gas cylinders.

Receiving and Storage:

1. Cylinders should not be accepted unless the cylinder contents are clearly labeled.
2. Do not accept cylinders which are damaged or do not have a valve protection cap.
3. Carefully read the label before storing any compressed gas. The SDS will provide

additional hazard and storage information.

4. Compressed gas cylinders must be capped with valve protection cap, stored in a well ventilated location and secured in an upright position with straps or chains at all times. **Chains** are preferable, as they will not burn during a fire and will continue to secure the cylinder.
5. Multiple compatible cylinders may be secured together, only if they are capped (not in use).
6. Never place oxygen cylinders (oxidizing gases) near highly combustible materials, especially oil and grease, near stocks of carbide and acetylene or other fuel gas cylinders, nor near any other substance likely to cause or accelerate a fire.
    - Systems and components used for other gases and purposes must never be used for oxygen or interconnected with oxygen.
    - Signs should be clearly posted in areas where flammable compressed gases are stored, identifying the gases and the appropriate precautions to be taken.
7. Cylinders should have current hydrostatic test date (normally less than 5 years old for steel and 3 years old for aluminum) engraved on the cylinder. Cylinders should be returned to the supplier for servicing prior to the expiration date.
8. Do not place cylinders near heat, sparks, or flames or where they might become part of an electrical circuit.
9. Do not store cylinders in exit corridors or hallways.

Handling and Use

1. Before using a cylinder, read all label information and safety data sheets associated with the gas being used. Check the SDS for required personal protective equipment and hazard information before use.
2. Only use approved regulators, fittings and components which are permitted for the type of gas in the cylinder.
3. Do not use adapters to interchange regulators.
4. Be careful when threading a regulator onto a cylinder. They can become stuck, causing the gas to be released from the cylinder. This may result in oxygen depletion of the room, or in the development of a flammable atmosphere in the room.
5. Open cylinder valves slowly and face away from the valve when opening it. Ensure that others are not facing the valve when you open it.
6. Never force a gas cylinder valve. If the valve cannot be opened by the wheel or small wrench provided, the cylinder should be returned.
7. Transferring gases from one cylinder to another, refilling cylinders, or mixing gases in a cylinder in the laboratory is prohibited.
8. Use appropriate hand carts to move cylinders. Cylinders must be secured to the cart during transport with protective caps in place. Do not move gas cylinders by rolling them.
9. cylinders must be secured in an upright position with straps or chains and placed in well ventilated area in the lab.
10. All gas cylinders should be clearly marked indicating whether they are in use, full, or empty.
11. Use a leak check solution to detect leaks. Leak test the regulator, pigtail connections, and any piping system after performing maintenance or making modifications which could affect the integrity of the system. Always use a leak check solution that is approved for oxygen whenever leak checking oxygen or nitrous oxide cylinders.
12. Oil or grease on the high pressure side of an oxygen cylinder can cause an explosion. Do not lubricate an oxygen regulator.
13. Cylinders of toxic, corrosive or reactive gases should be purchased in the smallest quantity possible and stored/used in an approved ventilated gas cylinder storage cabinet, fume hood or under other approved local exhaust ventilation.

4.2 Health Hazards

A chemical is a health hazard if there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Each health hazard is defined and briefly discussed below.

4.2.1 Irritants

Irritants are defined as chemicals that cause reversible inflammatory effects on living tissue by chemical action at the site of contact. A wide variety of organic and inorganic compounds, including many chemicals that are in a powder or crystalline form, are irritants. Symptoms of exposure can include reddening or discomfort of the skin and irritation to respiratory systems.

4.2.2 Sensitizers

A sensitizer (allergen) is a substance that causes exposed individuals to develop an allergic reaction in normal tissue after repeated exposure to the substance. Examples of sensitizers include diazomethane, chromium, nickel, formaldehyde, isocyanates, arylhydrazines, benzylic and allylic halides, and many phenol derivatives. Sensitizer exposure can lead to all of the symptoms associated with allergic reactions, or can increase an individual's existing allergies.

4.2.3 Corrosives

Corrosive substances cause destruction of living tissue by chemical corrosion at the site of contact and can be either acidic or caustic (basic). Major classes of corrosive substances include:

- Strong acids such as sulfuric, nitric, hydrochloric and hydrofluoric acids
- Strong bases such as sodium hydroxide, potassium hydroxide, and ammonium hydroxide
- Dehydrating agents such sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide
- Oxidizing agents such as hydrogen peroxide, chlorine, and bromine

Precautions to take when working with corrosives:

1. Eye protection and gloves should always be worn when handling corrosive materials. A face shield, rubber apron, and rubber boots may also be appropriate, depending upon the work performed (check the Safety Data Sheet for personal protective equipment requirements).
2. Always add acid to water. Dehydrating agents such as sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide should be mixed with water by adding the agent to water to avoid violent reaction and splattering.
3. An eyewash and safety shower must be immediately accessible in areas where corrosives are used and/or stored. In the event of skin or eye contact, immediately flush the area of contact with cool water for 15 minutes and remove all affected clothing. Get medical help immediately.
4. Strong oxidizing agents such as chromic and perchloric acids should be stored and used in glass or other inert containers (preferably unbreakable); corks and rubber stoppers should not be used
5. Safety rubber bottle carriers or non-breakable bottles (PVC-coated) should be used for the transport of strong acids and bases from one location to another.

Corrosive Materials Storage

The best storage method for corrosive materials is inside of a corrosive storage cabinet or lab cabinet where acids and bases are segregated at all times. Acids must also be segregated from chemicals where a toxic gas would be generated upon contact with an acid (e.g., cyanide or sulfide compounds). Organic acids (e.g., acetic acid, formic acid) must be stored away from oxidizing acids (e.g., nitric acid, perchloric acid), as these types of acids are incompatible with each other. Segregation can be achieved either by physical distance (preferred method) or by secondary containment.

4.2.4 Hazardous Substances with Toxic Effects on Specific Organs

Substances with toxic effects on specific organs include:

- **Hepatotoxins**, which are substances that produce liver damage, such as nitrosamines and carbon tetrachloride.
- **Nephrotoxins**, which are substances that cause damage to the kidneys, such as certain halogenated hydrocarbons.
- **Neurotoxins**, which are substances that produce toxic effects on the nervous system, such as mercury, acrylamide, and carbon disulfide.
- Substances that act on the **hematopoietic system** (e.g., carbon monoxide and cyanides), which decrease hemoglobin function and deprive the body tissues of oxygen.
- Substances that **damage lung tissue** such as asbestos and silica.

4.2.5 Particularly Hazardous Substances

Substances that pose such significant threats to human health are classified as "particularly hazardous substances" (PHSs). The OSHA Laboratory Standard requires that special provisions be established to prevent the harmful exposure of researchers to PHSs, including the establishment of designated areas for their use. Particularly hazardous substances are divided into three primary types:

1. Carcinogens
2. Reproductive Toxins
3. Substances with a High Acute Toxicity

4.2.5.1 Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally, they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. Chronic toxins are particularly insidious because they may have no immediately apparent harmful effects. These materials are separated into two classes:

1. **Select Carcinogens:** Select carcinogens are materials which have met certain criteria established by the National Toxicology Program or the International Agency for Research on Cancer regarding the risk of cancer via certain exposure routes. It is important to recognize that some substances involved in research laboratories are new compounds and have not been subjected to testing for carcinogenicity.
2. **Regulated Carcinogens:** Regulated carcinogens are more hazardous and have extensive additional requirements associated with them. The use of these agents may require personal exposure sampling based on usage. When working with Regulated Carcinogens, it is particularly important to review and effectively apply engineering and administrative safety controls as the regulatory requirements for laboratories that may exceed long term (8 hour) or short term (15 minutes) threshold values for these chemicals are very extensive.

4.2.5.2 Reproductive Toxins

Reproductive toxins include any chemical that may affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogens).

Reproductive toxins can affect the reproductive health of both men and women if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus; these effects include embryolethality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. For men, exposure can lead to sterility. Examples of embryotoxins include thalidomide and certain antibiotics such as tetracycline. Women of childbearing potential should note that embryotoxins have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin (e.g., formamide).

4.2.5.3 Substances with a High Acute Toxicity

Substances that have a high degree of acute toxicity are materials that may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration.

Acute toxins are quantified by a substance's lethal dose-50 (LD50) or lethal concentration-50 (LC50), which is the lethal dose of a compound to 50% of a laboratory tested animal population (e.g., rats, rabbits) over a specified time period. High acute toxicity includes any chemical that falls within any of the following OSHA-defined categories:

- A chemical with a median lethal dose (LD50) of 50 mg or less per kg of body weight when administered orally to certain test populations.
- A chemical with an LD50 of 200 mg less per kg of body weight when administered by continuous contact for 24 hours to certain test populations.
- A chemical with a median lethal concentration (LC50) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable manner.

Precautions

Precautions to take when working with carcinogens, reproductive, or highly toxic chemicals:

Know the hazards of the material you are using. Review the SDS and do additional research if necessary. Use less toxic materials when possible.

Use and store toxic chemicals in established areas and in the smallest possible amounts.

Store and transport toxic chemicals in secondary containment.

Use these materials in containment devices such as fume hoods and glove boxes.

2. Use appropriate protective equipment.
3. Be prepared for spills and know when to take emergency action.
4. Wash hands and arms immediately after working with toxic materials.
5. Never eat, drink, smoke, apply cosmetics, take medication, adjust contacts, or store food in areas where toxic substances are being used.
6. Dispose of wastes in accordance with Chemical Waste Management Procedures. As appropriate, perform chemical decontamination of washes and materials from experiments.
7. Consider whether additional precautions are needed for substances with high toxicity.
    - Areas to be designated for use and posted, e.g., fume hood, glove box, or entire room;
    - Containment devices (e.g., fume hood or glove box);
    - Procedures for decontamination and waste disposal; and
    - Additional training or personal protective equipment for material users.

Acutely Toxic Materials Storage

The following guidelines for storing acutely toxic materials must be followed in all laboratories:

1. Suitable storage locations for acutely toxic materials include desiccators, glove boxes, flammable storage cabinets that do not contain incompatible chemicals (primarily strong acids), or non-domestic refrigerators or freezers. These locations should be clearly labeled.
2. Acutely toxic materials should be stored in secondary containment at all times as a best management practice.
3. If possible, store all acutely toxic materials in a cabinet dedicated only for acutely toxic materials. Signs should be posted to indicate their presence and unique hazards.
4. The amount of acutely toxic material stored in the lab should be kept at a minimum. Any expired or unnecessary materials must be properly disposed of as hazardous waste.
5. All acutely toxic materials should be clearly labeled with the original manufacturer's label, which should have the chemical name, hazard labels, and pictograms. The label should not be defaced in any way.

4.2.6 Cryogenic Liquids

A cryogenic liquid is defined as a liquid with a normal boiling point below -150 °C (-238 °F). The most common cryogenic liquid used in a laboratory setting is liquid nitrogen. By definition, all cryogenic liquids are extremely cold. Cryogenic liquids and their vapors can rapidly freeze human tissue and can also pose an asphyxiation hazard if handled without proper ventilation. The following precautions should be taken when handling cryogenic liquids:

1. Read safety data sheet for the cryogenic liquid and check the hazard information before use.
2. Use and store cryogenic liquids in well ventilated areas only to avoid localized oxygen depletion (asphyxiation risk) or buildup of flammable or toxic gas.
3. Guard against skin damage by wearing appropriate PPE while handling cryogenic liquids. Proper PPE for handling cryogenic liquids includes chemical splash goggles, a face shield, cryogenic-safe gloves, long sleeves, as well as a garment and fully enclosed shoes covering all skin beneath the waist.
4. Cryogenic liquids will vent (boil off) from their storage containers as part of normal operation. Containers are typically of a vacuum jacketed design to minimize heat loss. Excessive venting and/or an isolated ice build-up on the vessel walls may indicate a fault in the vessel's integrity or a problem in the process line. A leaky container should be removed from service and taken to a safe, well-ventilated area immediately.
5. All systems components piping, valves, etc., must be designed to withstand extreme temperatures.
6. Pressure relief valves must be in place in systems and piping to prevent pressure build up. Any system section that could be valved off while containing cryogenic liquid must have a pressure relief valve. The pressure relief valve relief ports must be positioned to face toward a safe location.
7. Transfer operations involving open cryogenic containers, such as Dewars must be done slowly, while wearing all required PPE. Care must be taken not to contact non-insulated pipes and system components.
8. Transfers or pouring of cryogenic liquids should be done carefully to avoid splashing.
9. Do not use a funnel while transferring cryogenic liquids.
10. Use tongs or other similar devices to immerse and remove objects from cryogenic liquids; never immerse any part of your body into a cryogenic liquid.

4.2.7 Nanomaterials

Nanotechnology is the understanding, manipulation, and control of matter at dimensions of roughly 1 to 100 nanometers, which is near-atomic scale, to produce new materials, devices, and structures. One nanometer is one-billionth of a meter. Putting this size into perspective, a single human hair is about 80,000 nanometers in width and a red blood cell is about 7,000 nanometers in diameter.

Engineered nanoscale materials or nanomaterials are materials that have been purposefully manufactured, synthesized, or manipulated to have a size with at least one dimension in the range of approximately 1 to 100 nanometers and that exhibit unique properties determined by their size. In many cases, particles created at the nanoscale are found to have different chemical and physical properties than larger particles of the same material

Exposure to nanomaterials can occur through inhalation, absorption, injection, or ingestion. Toxicity will depend on the route of exposure and physical and chemical properties of the nanomaterial. Nanomaterials with known hazardous properties (e.g., carcinogens, mutagens, reproductive toxicants, sensitizers, reactive metals, etc.) as well as those that are photo-reactive, have highly-charged surfaces, are highly acidic/basic, soluble, fibrous (i.e., possess a high aspect ratio), and/or have other hazardous properties require further assessment and control measures.

Refer to the General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories for detailed procedures and guidance regarding the safe handling of nanomaterails.

5.0 Controlling Hazardous Chemicals

Laboratory Safety Considerations

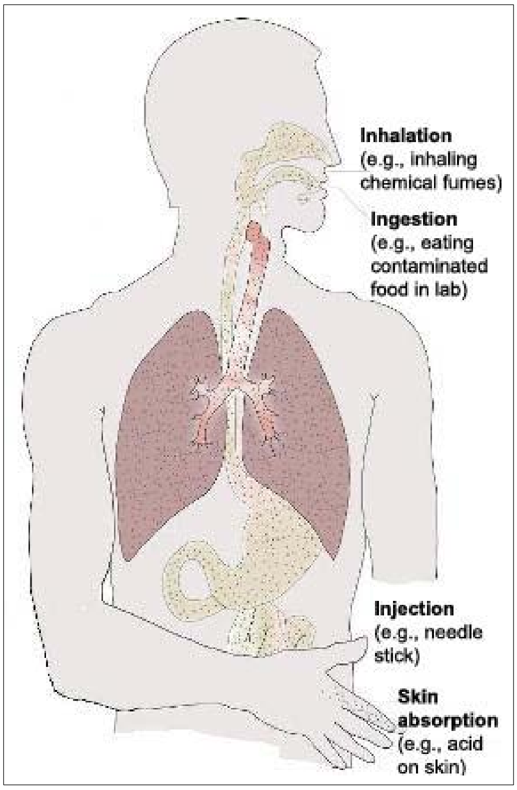
Many factors are involved in an effective laboratory safety plans. Considering the following questions will help address many of the factors that should be considered before work in the lab begins:

- Is the material flammable, explosive, corrosive, or reactive?
- Is the material toxic, and if so, how can I be exposed to the material (e.g., inhalation, skin or eye contact, accidental ingestion, accidental puncture)?
- What kind of ventilation do I need to protect myself?
- What kind of PPE (e.g., chemical-resistant gloves, respirator, and goggles) do I need to protect myself?
- Will the process generate other toxic compounds, or could it result in a fire, explosion, or other violent chemical reaction?
- What are the proper procedures for disposal of the chemicals?
- Do I have the proper training to handle the chemicals and carry out the process?
- Are my storage facilities appropriate for the type of materials I will be using?
- Can I properly segregate incompatible chemicals?
- What possible accidents can occur and what steps can I take to minimize the likelihood and impact of an accident? What is the worst incident that could result from my work?

5.1 Routes of Exposure

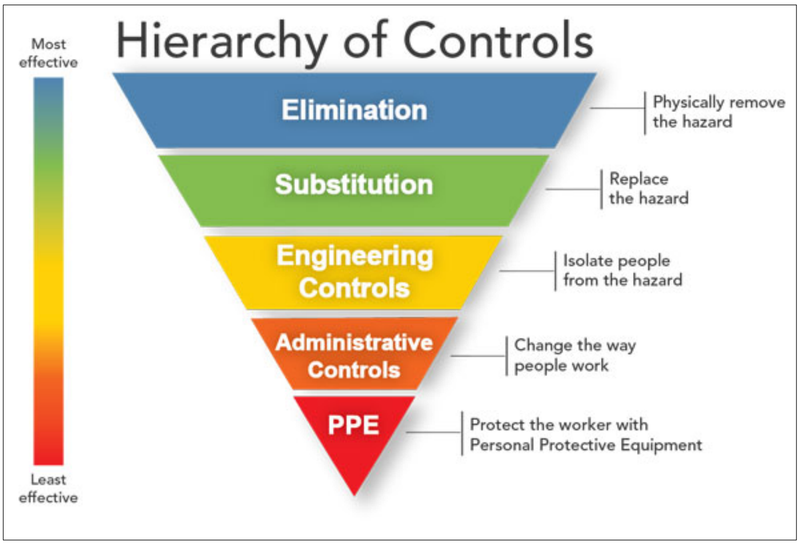
There are four primary routes of exposure in which hazardous substances can enter the body: inhalation, absorption (through skin or eyes), ingestion, and injection. Of these, the most likely routes of exposure in the laboratory are by inhalation or absorption so it is critical that protective measures must be in place for each of these exposure routes.

- **Inhalation**: Inhalation of gases, vapors, dusts, fumes or mists is a common route of exposure. Chemicals can enter and irritate the nose, airways and lungs. They can become deposited in the airways or be absorbed through the lungs into the bloodstream. The blood can then carry these substances to the rest of the body.
- **Absorption or Direct (skin/eye) contact**: Many chemicals can injure the skin directly (corrosives), while others may cause irritation or an allergic reaction. In addition to causing local effects, many chemicals may be absorbed through the skin and/or eyes in sufficient quantity to cause systemic effects. The main avenues by which chemicals enter the body through the skin are hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the skin. Direct contact effects and absorption of chemicals through the skin depend on a number of factors, including chemical concentration, chemical reactivity, solubility of the chemical in fat and water, condition of the skin, and duration of contact.
- **Ingestion**: Chemicals that get in or on food, cigarettes, utensils or hands can be swallowed. Substances can be absorbed into the blood and then transported to the rest of the body.
- **Injection**: Injections can occur through needles or broken contaminated glassware.



5.2 Hierarchy of Controls

Procedures must be followed in laboratories to both control the hazard and control worker exposure to the hazard. The hierarchy of controls prioritizes hazard mitigation strategies on the premise that the best way to control a hazard is to



5.2.1 Eliminate

the hazard from the workplace or

5.2.2 Substitute

with a less hazardous technique, process, or material.

If **elimination or substitution** are not feasible options; engineering controls, administrative controls, and PPE must be used to provide the necessary protection.

5.2.3 Engineering Controls

Engineering controls seek to control hazards at their source by designing the work environment or the job itself to eliminate or reduce exposure to hazards. A fundamental and very common example is the laboratory fume hood which is very effective at containing chemical hazards and protecting users from inhalation hazards. Other examples of engineering controls include general room ventilation, flammable material storage units, and secondary containment.

5.2.3.1 Fume Hoods

Fume hoods are the most important engineering control used in labs to protect workers from exposure to hazardous chemicals

To determine if a chemical is required to be used inside of a chemical fume hood, first check the SDS for that chemical. Statements found in Section 2 on a SDS such as “do not breathe dust, fumes, or vapors” or “toxic by inhalation” indicate the need for ventilation. As a best practice, always use a chemical fume hood for all work involving the handling of open chemicals (e.g., preparing solutions, transferring chemicals) whenever possible.

The following general rules should be followed when using laboratory hoods:

1. Wear appropriate personal protective equipment (PPE) at all times.
2. Place all materials in the fume hood at least 6 inches away from the edge of the fume hood face. When work is carried out within 6 inches of the edge, vapors, fumes, and particles are more likely to escape.
3. Work with the hood sash in the lowest practical position. The sash acts as a physical barrier in the event of an accident. Keep the sash closed when not conducting work in the hood.
4. Do not clutter your hood with unnecessary bottles or equipment that can block air circulation. Keep it clean and clear. Only materials actively in use should be in the hood.

5. Chemical fume hoods used for experimental work should not be used for chemical or equipment storage. Store chemicals in appropriate locations, such as a flammable storage cabinet, and bring them into the fume hood only when needed.
6. Never put your head inside of an operating chemical fume hood.
7. Keep the hood sash closed when not in use to safe energy.
8. Do not use the hood to volatilize chemicals or wastes
9. Never use electrical outlets inside the hood. Run all equipment cords to outlets outside of the hood.
10. Elevate large equipment (e.g., a centrifuge) at least two inches off the base of the hood interior.
11. Fume hoods must remain working at all times when chemicals are present in the hood.
12. Chemical fume hoods should be inspected upon installation, renovation, when a deficiency is reported, or a change has been made to the operating characteristics of the hood.
13. Never work in a fume hood that is not running properly. Remove chemicals from hood, close the sash, and contact CL Engineers

5.2.3.2 Other Sources of Ventilation

In addition to fume hoods other forms of ventilation including gloveboxes, biosafety cabinets, canopy hoods, clean benches, ductless fume hoods, etc. may be present in labs.

Glove boxes:

Glove boxes may be used for working with reactive chemicals under an inert environment or for working with very toxic substances in a completely closed system. These units can be very effective because they offer complete containment.

Biosafety cabinet:

A biological (or biosafety) safety cabinet is an enclosed, ventilated laboratory workspace used for safely working with materials contaminated with (or potentially contaminated with) infectious materials. The primary purpose of a biosafety cabinet is to serve as a means to protect the laboratory worker and the surrounding environment from pathogens. All exhaust air is filtered as it exits the biosafety cabinet, removing harmful particles.

Biological safety cabinets are not designed to be used with chemical applications so never use hazardous chemicals in these cabinets. Applications that involve the use of chemicals should be conducted in chemical fume hoods.

5.2.3.3 Refrigerators and Freezers

Flammable-safe refrigerators and Freezers are designed to eliminate ignition of flammable vapors inside the storage compartment (by locating the compressor and other circuits that can arc/create a spark on the exterior of the unit).

The following procedures must be followed when storing chemicals in refrigerators or freezers in the laboratory:

1. Never use a domestic refrigerator to store flammables because they contain ignition sources that can set off explosive concentrations of flammable vapor. Vapors from a leaky stopper or a cracked container can build up to explosive concentrations and be ignited by the light switch or thermostat.
2. Domestic refrigerators/freezers located in labs must be labeled "Do Not Store Flammables in This Refrigerator/freezer."
3. Flammable chemicals must be stored in an approved explosion-proof or flammable storage refrigerator or freezer.

4. Ensure that the chemicals stored in a refrigerator or freezer is compatible with each other. For example, do not store an oxidizer such as hydrogen peroxide in a refrigerator with organic chemicals. Limited quantities of incompatible hazard classes that require refrigeration must be segregated in separate secondary containment bins with tight-fitting caps or lids.
5. Never store uncapped or partially opened containers (e.g., chemicals covered with aluminum foil, glass stoppers, wooden corks, etc.) of chemicals in a refrigerator/freezer.
6. Samples and chemicals stored in refrigerators must be appropriately labeled.
7. Shelves in refrigerators or freezers should all have suitable plastic trays for secondary containment in the refrigerator and freezer compartments. If plastic trays are not available, liquid chemicals should be placed in secondary containers to contain spills.
8. An inventory should be posted on the refrigerator door.
9. Chemical refrigerator or freezers should be located away from laboratory exits.
10. Refrigerators and freezers should be cleaned-out and manually defrosted as necessary.
11. When defrosting a freezer, safety precautions should be taken regarding potential chemical contamination of the water.
12. Remember that power outages and technology failures can cause internal temperatures to rise, which can impact chemical contents. Be aware of unusual odors, vapors, etc., when opening the refrigerator or freezer.

Cold rooms in W12 and M32 are not designed for storage of flammable or volatile materials. They may have exposed ignition sources and are not ventilated to actively remove chemical contaminants. Therefore, undesirable vapors may become concentrated if these types of materials are stored in cold rooms.

5.2.3.4 Chemical Storage Cabinets

Chemical storage cabinets are designed to store flammable liquids, corrosives, and other hazardous materials to help protect lab personnel and facility from a potential fire or spillage. These cabinets are typically made from materials that are resistant to the chemicals stored in them and occasionally contain a tray to capture spillage. Chemical storage cabinets are usually suited for specific classes of chemicals. Acid cabinets, for example, consist of corrosion-resistant materials and sealing to prevent the leakage of fumes. Flammable solvent cabinets are produced from a metal able to resist fire for at least 10-30 minutes. The cabinet features include:

- Keep dangerous liquids safely organized and segregated
- Ensure safe evacuation time in the event of a fire
- Provide compliance with local and international regulations.
- Manage quantities of flammable and combustible liquids in control areas.
- Improve efficiency by locating materials near point-of-use.
- Improve security with locking mechanism.

5.2.4 Administrative Controls

Administrative controls are policies, work practices, and procedures designed to limit or prevent personnel exposure to workplace hazards. Administrative controls are often used in conjunction with engineering controls and personal protective equipment. Examples of administrative controls include:

5.2.4.1 Information and Training

All lab employees who works with, or is exposed to potentially hazardous chemicals in a laboratory must read and understand the chemical hygiene plan to know the hazards of those chemicals and the control measures that should be taken to avoid the exposure.

Central Labs Directorate is providing general lab safety training though an online training system. However, training specific on hazards of chemicals, equipment, or operations for the particular lab where an employee is assigned is the responsibility of that employee's supervisor and his/her department, and must be provided before initial assignment. Documentation of the training, including the content, training date, and signatures, is recommended. See Appendix 2

The intent of training is to assure that all employees are informed about hazards and protection when working in the lab.

Laboratory employees should be familiar of the location and content of the following:

- Chemical Hygiene Plan
- Safety Data Sheets (SDSs)
- Central labs safety manual
- Emergency Response Guide

5.2.4.2 General Laboratory Safety Rules

The following general laboratory safety rules should be followed by lab personnel at all times:

1. **Working alone**. Avoid working alone in the laboratory. If you must work alone or in the evening, let someone else know and have them periodically check on you. However, **never** work with high hazard chemicals or perform high hazard operations alone. Notify others in the lab that you will be working with highly hazardous chemicals and plan your work so that this is done during normal working hours.
2. **Housekeeping**:
   2.1 Proper housekeeping includes appropriate labeling and storage of chemicals, safe and regular cleaning of the facility, and proper arrangement of laboratory equipment.
   2.2 Exits, aisles and Emergency equipment must not be obstructed in any way with equipment, furniture, supplies, etc.
   2.3 All work areas and floors should be kept free of clutter and not to be used for excessive storage.
3. **Equipment, tools, and glassware**. Use proper equipment that is in good condition. never use chipped or cracked glassware. Shield pressurized or vacuum apparatus and safeguard against bumping or overheating.
4. **Chemical wastes**. Properly dispose of chemical wastes as per the procedures outlined in this document.
5. **Lab Emergencies**. Prior to beginning work in the lab, be prepared for hazardous materials emergencies and know what actions to take in the event of an emergency. Plan for the worst-case scenario. Be sure that necessary supplies and equipment are available for handling small spills of hazardous chemicals. Know the location of safety equipment such as the nearest safety shower and eyewash station, fire extinguisher, spill kit, and fire alarm call points.
6. **Chemical Information.** Always read and understand the SDS, and the label before using a chemical in the laboratory and make others in the laboratory aware of any special hazards associated with your work.
7. **Personal Hygiene**. Wash hands with soap and water immediately after working with any laboratory chemicals, even if gloves have been worn. Remove contaminated clothing and gloves before leaving laboratory. Never touch your cell phone, door handles, elevator buttons, etc. with gloved hands.
8. **Mouth pipetting**. Mouth pipetting is forbidden only use mechanical devices, such as pipet bulbs, pipet wheels, electric pipettes, etc.
9. **Food, drink and cosmetics**. Eating, drinking, and the application of cosmetics are forbidden in areas where hazardous chemicals are used. Do not store food or drink in the same refrigerator with chemicals.
10. **Never** smell or taste a hazardous chemical.
11. **Wear appropriate PPE** when handling hazardous materials.
12. **Signs and Posters**. Using safety signs or posters to identify hazardous areas (designated areas).

13. **Appropriate ventilation** Always use adequate ventilation with chemicals. Operations using volatile or toxic substances should only be performed in a chemical fume hood.
14. **Unattended operations**. If you are doing laboratory work involving hazardous substances that occur continuously or overnight, when no one is present in the laboratory, you need to post a sign on the fume hood or at the door to the lab, indicating your name, contact information, and hazardous materials involved. It is the responsibility of the researcher/lab supervisor to design the overnight reactions with control measures to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas.
15. **Risk assessments**. Carry out risk assessments when planning out experiments, before beginning new processes or operations. See Appendix 3
16. **Safety Training.** Complete required safety training prior to beginning work. Training is required before beginning work with chemicals in a University laboratory.
17. **Malfunctioning** laboratory equipment (such as a chemical fume hood) should be identified as "out of service" so that others will not inadvertently use it before repairs are made. Contact CLD Maintenance Section to repair fume hood as soon as possible.
18. **Laboratory Security:** For liability, safety, and security reasons, do not allow unauthorized persons in the laboratory and restricting access to areas where hazardous materials are used. Laboratories shall be closed when no one is present.
19. **Prior Approvals.** Obtain prior approval to proceed with a laboratory procedure from the lab supervisor/ lab faculty member when:
    - Working with highly hazardous substances (highly toxic gases, extremely reactive chemicals, etc.)
    - Performing particularly hazardous procedures (i.e., potential for violent reaction); and/or
    - Working alone with particularly hazardous materials or hazardous procedures
    - Leaving operations unattended
20. **Never** perform unauthorized experiments.
21. **Horseplay**. Horseplay is prohibited.
22. **Particularly dangerous chemicals.** Use only those chemicals for which you have the appropriate exposure controls, for example, Perchloric acid. If Perchloric acid is heated above ambient temperature it will give off vapors that can condense and form explosive perchlorates. Hence, when heating Perchloric acid above ambient temperature, a Perchloric acid hood with a wash down system or a local scrubbing or trapping system should be used.
23. **Mercaptans**. To avoid false reporting of natural gas leaks, logs of mercaptan use should be kept when Mercaptans will be used in a laboratory and you should inform Central Labs Directorate to notify the lab staff for the smell as the persons outside the laboratory could smell the mercaptan and suspect a natural gas leak in the building.
24. **Incident Reporting**. Report all injuries, accidents, incidents, and near misses to CLD.

5.2.4.3 Standard Operating Procedures (SOPs)

SOPs are written instructions that clearly outlines the steps to be followed when carrying out a given operation or experiment so that a process can be performed in a safe manner by any person reading it. These SOPs should address hazards of the activity or material(s) as well as the safety measures necessary to protect personnel and students from the exposure to hazardous materials in the laboratory.

This general chemical hygiene plan, along with safety data sheets (SDS), may be sufficient as the primary source of information for pre-planning certain simple lab activities or experiments. However, laboratory personnel/researchers who are the most knowledgeable and involved with the experimental process are required to develop more detailed procedures as their situations warrant. Priority for SOP development should be given to any operation involving restricted and higher hazard chemicals, such as Particularly Hazardous Substances and Highly Reactive Chemicals, and specified higher-risk research procedures. The SOP needs to be approved by the lab/research supervisor.

The SOP needs to contain the following information at a minimum:

1. Process or Experiment Description
2. Risk Assessment
   - 2.1. Identify Hazards
   - 2.2. Potential risks
   - 2.3. Control of Hazards
     - 2.3.1. Engineering/Ventilation Controls
     - 2.3.2. Administrative controls
       - 2.3.2.1. Special Handling Procedures and Storage Requirements
       - 2.3.2.2. Training Requirements
       - 2.3.2.3. Prior Approval
     - 2.3.3. Personal Protective Equipment
3. Step-By-Step Operating Procedure
4. Waste Disposal
5. Emergency Procedures
   - 5.1. Emergency Equipment
   - 5.2. Spill and Accident Procedures
   - 5.3. Decontamination Procedures
   - 5.4. First Aid Procedures
6. Document training on the SOP

Labs may use a standard SOP template provided in Appendix 4

5.2.5 Personal Protective Equipment

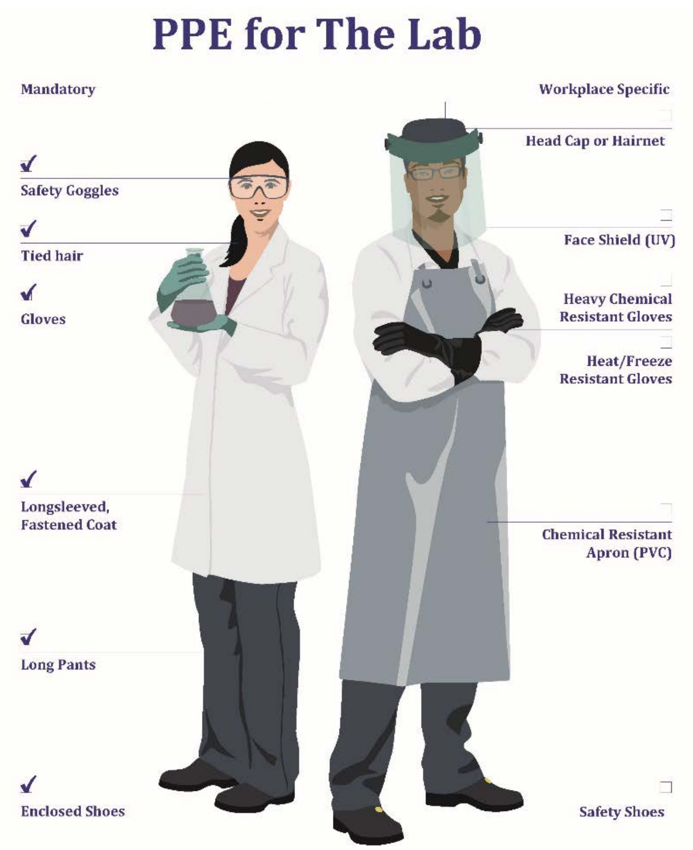
Appropriate PPE is essential for personal protection and is used in combination with engineering and administrative controls. PPE alone does not provide adequate control of hazardous chemicals but is an effective method to reduce exposure in the event that engineering and administrative controls cannot adequately minimize the risk as it is creating a barrier against workplace hazards. PPE should never be used as a substitute for engineering controls when engineering controls are required. The minimum PPE that must be worn at all time in labs where hazardous chemicals are handled are goggles or safety glasses, clothing that covers the legs, and closed-toed footwear. Proper PPE selection can be determined from the following resources:

- Review Section 8, "Exposure Controls/Personal Protection" of the SDS for the chemical(s) being used. This will provide basic information on the PPE recommended for use with the particular chemical.
- Review the SOP and associated risk assessment for the task to be performed.

It is the responsibility of the lab supervisors/researchers to determine what PPE is necessary for the specific task they are performing. See Appendix 8 for PPE Selection Guide.

In general, Personal Protective Equipment (PPE) includes:

- **Protective Clothing** that covers a majority of the skin to protect from spills (e.g., laboratory coats)
- **Eye/Face Protection** should be worn when working with chemicals (e.g., safety glasses, goggles, face shield) splash goggles should be considered, especially when working with concentrated acids or any harmful chemical.
- **Hand Protection** to match the hazard (e.g., chemical-resistant gloves, thermal protection gloves, cut-resistant gloves) you may use the [Ansel Online Chemical Hand Protection Guide]() to find the proper gloves
- **Protective Footwear** (e.g., safety shoes, closed shoes) (sandals, flip-flops, clogs, or other footwear that expose the front, top, side or back of the feet are not allowed).
- **Hearing Protection** (e.g., earplugs, ear muffs)
- **Respiratory Protection** (e.g., N95 filtering face-piece, half-face respirator).



6.0 Emergency Procedures

Laboratory emergencies may result from a variety of factors, including serious injuries, fires and explosions, spills and exposures, and natural disasters and can cause serious consequences as personal injury, property damage, environmental impact, and disruption of academic research, so it is best to be prepared before it happens. Spend time before each semester to become familiar with the location and use of Emergency Response Guide/Poster, safety manuals, Safety Data sheets, and Emergency Equipment such as first aid kits, safety showers, eyewash stations, fire extinguishers, circuit breakers, fire alarm call points, and spill kits. **All lab emergencies must be reported to Central Labs Directorate** through an Incident Report which can be found online on Central Labs Safety Portal. The report should be completed within 24 hours of the incident. In emergency situations you must contact the UOS Emergency Numbers for help, see Appendix 11.

General procedures to be followed in any emergency are found in the CLD Emergency Response Guide.

6.1 Medical Examination and Consultation

Laboratory personnel shall seek medical attention under the following conditions:

- An individual develops signs or symptoms associated with exposure to hazardous chemicals in the laboratory.
- An accident such as a spill, leak, equipment failure, or explosion results in possible over-exposure to hazardous chemicals.
- Any work-related injury

Information Provided to Physician

The following information must be provided to the examining physician.

- The SDS for the applicable hazardous chemical(s)
- The conditions and type of exposure.
- The signs and symptoms of exposure that the person is experiencing, if any

Upon completion of the examination, the physician will provide the medical reports includes the following:

- Examination and test results.
- Recommendations for further follow up examination.
- Any medical condition of the employee which places them at risk as a result of exposure to hazardous chemicals found in their workplace

* The medical reports must be submitted to CLD.

6.2 Don't Learn Safety by Accident

Lab personnel are encouraged to browse the below incidents or use the google search to locate related reports. Use Lessons learned to improve safety in your lab.

Texas A&M-Qatar cancels classes after staffer killed in laboratory accident

Refrigerator Explosion at Michigan State University

Texas Tech University Chemistry Lab Explosion

Gas Cylinder Explosion Kills Researcher at Indian Laboratory

The University of California, Los Angeles lab fire fatality

Yale Student Killed in lab accident as Hair Gets Caught in Lathe A

Dartmouth researcher died from exposure to dimethyl mercury

Graduate student gets prison sentence for poisoning

For more lab accidents click here

7.0 References and Additional Resources

Additional information on safety in chemical laboratories can be found in the following publications.

- **Identifying and Evaluating Hazards in Research Laboratories**. These are the 2015 guidelines developed by the hazards identification and evaluation task force of the American Chemical society's (ACS's) committee on chemical safety.
- **Prudent Practices for Handling Hazardous Chemicals in the Laboratory** issued by National Research Council and published by National Academy Press.
- **Safety in the use of chemicals at work** by the International Labour Office in Geneva.
- The **National Institute for Occupational Safety and Health (NIOSH) guide** to Chemical Hazards published by the CDC.
- ACS publications **Safety in Academic Chemistry Laboratories Vol 1** *Accident prevention for college and university students* and **Accident prevention for faculty and administrators**.
- **OSHA Laboratory Safety Guidance**
- **Hazard Assessment in Research Laboratories**
- **Promoting a Culture of Safety in Academic Chemical Research (2014)**
- **Chemical Laboratory Safety and Security:** A Guide to Developing Standard Operating Procedures (2016)
- A Guide to The Globally Harmonized System of Classification and Labeling of Chemicals (GHS)
- **OSHA Hazard Classification Guidance**

8.0 Appendices

8.1 Appendix 1: Definitions

Absorbed Dose. The amount of a substance that actually enters into the body, usually expressed as milligrams of substance per kilogram of body weight (mg/kg).

ACGIH. The American Conference of Governmental Industrial Hygienists is an organization of government and academic professionals engaged in occupational safety and health programs. ACGIH establishes recommended occupational exposure limits for chemical substances and physical agents known as Threshold Limit Values; see TLV.

Acute. Short duration, rapidly changing conditions.

Acute Exposure. An intense exposure over a relatively short period of time.

Acute Dose. The amount of a substance administered or received over a very short period of time (minutes or hours), usually within 24 hours.

Acute Toxicity. Those adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.

Alkali. (Also referred to as a base). A compound that has the ability to neutralize an acid and form a salt. Alkali also forms a soluble soap with a fatty acid. Alkalis have pH values between 7 and 14. They are bitter in a water solution. Alkalis with pH values between 12 and 14 are considered to be corrosive (caustic) and will cause severe damage to the skin, eyes and mucous membranes. Common strong alkalis are the substance sodium and mixture potassium hydroxide.

Allergic Reaction. An abnormal immunologic response in a person who has become hypersensitive to a specific substance. Some forms of dermatitis and asthma may be caused by allergic reactions to chemicals.

ANSI. The American National Standards Institute is a privately funded, voluntary membership organization that identifies industrial and public needs for national consensus standards and coordinates development of such standards.

Asphyxiant - A chemical (gas or vapor) that displaces oxygen in the ambient atmosphere, and can thus cause oxygen deprivation in those who are exposed, leading to unconsciousness and death. Simple asphyxiants, such as nitrogen, either remove or displace oxygen in the air. They become especially dangerous in confined or enclosed spaces. Chemical asphyxiants, such as carbon monoxide and hydrogen sulfide, interfere with the body's ability to absorb or transport oxygen to the tissues.

Aspiration. The entry of a liquid or solid chemical directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system.

ASTM. The American Society for Testing and Materials develops voluntary consensus standards for materials, products, systems, and services. ASTM is a resource for sampling and testing methods, information on health and safety aspects of materials, safe performance guidelines, and effects of physical agents, biological agents, and chemicals.

Autoignition Temperature. The lowest temperature at which a flammable gas or vapor-air mixture will spontaneously ignite without spark or flame. Vapors and gases will spontaneously ignite at lower temperatures as the concentration of oxygen increases in the air. The autoignition temperature may also be influenced by the presence of catalytic substances. Materials should not be heated to greater than 80% of the autoignition temperature.

Boiling Point (BP). The temperature at which a liquid changes to a vapor state, at a given pressure; usually expressed in degrees of Fahrenheit or Centigrade at sea level pressure (760 mm Hg or one atmosphere). Flammable materials with low boiling points generally present special fire hazards.

- **Initial boiling point** is the temperature of a liquid at which its vapor pressure is equal to the standard pressure (101.3 kPa; 14.7 psi), i.e., the first gas bubble appears.

CAS Number. A number assigned to a specific chemical by the Chemical Abstracts Service, an organization operated by the American Chemical Society. CAS Numbers are used internationally to identify specific chemicals or mixtures.

Carcinogen*.* A substance or a mixture of substances which induce cancer or increase its incidence. Substances and mixtures which have induced benign and malignant tumors in well-performed experimental studies on animals are considered also to be presumed or suspected human carcinogens unless there is strong evidence that the mechanism of tumor formation is not relevant for humans.

Chemical Hygiene Plan (CHP). Is a written program stating the policies, procedures and responsibilities that protect workers from the health hazards associated with the hazardous chemicals used in that particular workplace.

Chronic Toxicity. Adverse effects resulting from repeated doses or exposures to a substance over a relatively prolonged period of time.

Controlled Substances. Drugs and certain other chemicals, both narcotic and non-narcotic, which come under the jurisdiction of federal Drug Enforcement Administration (DEA) and state laws regulating their manufacture, sale, distribution, use, and disposal.

Combustible Liquid. Any liquid having a flash point at or above 100ºF (37.8ºC) but below 200ºF (93.3ºC), except for mixtures having components with flash points of 200ºF (93.3ºC) or higher, the total volume of which makes up 99% or more of the total of the mixture.

Decomposition. Breakdown of a material or substance into simpler substances by heat, chemical reaction, electrolysis, decay, or other processes.

DNA. Deoxyribonucleic acid; the molecules in the nucleus of the cell that contain genetic information.

Dose. The amount of a substance received at one time. Dose is usually expressed as administered or absorbed dose (e.g., milligrams material/kilogram of body weight).

DOT. U.S. Department of Transportation; the federal agency that regulates transportation of chemicals and other hazardous and non-hazardous substances.

EPA - The Environmental Protection Agency - the governmental agency responsible for administration of laws to control and/or reduce pollution of air, water, and land systems.

Epidemiology. The branch of science concerned with the study of human disease in specific populations, in order to develop information about the causes of disease and identify preventive measures.

Explosive Limits. The range of concentrations of a flammable gas or vapor (percent by volume in air) in which an explosion can occur if an ignition source is present. Also see Flammable Limits, LEL, and UEL.

Explosive chemical. A solid or liquid chemical which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic chemicals are included even when they do not evolve gases.

- **Pyrotechnic chemical.** A chemical designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative self-sustaining exothermic chemical reactions.
- **Explosive item**. An item containing one or more explosive chemicals.
- **Pyrotechnic item**. An item containing one or more pyrotechnic chemicals.
- **Unstable explosive**. An explosive which is thermally unstable and/or too sensitive for normal
- **Intentional explosive**. A chemical or item which is manufactured with a view to produce a practical explosive or pyrotechnic effect.

Flammable. A material which is easily ignited and burns with extreme rapidity. The two primary measures of this physical hazard are the flashpoint and the autoignition temperature.

Flammable gas. A gas having a flammable range with air at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi).

Flammable liquid. A liquid having a flashpoint of not more than 93°C (199.4°F).

Flammable solid. A solid which is a readily combustible solid, or which may cause or contribute to fire through friction.

- **Readily combustible solids**. Powdered, granular, or pasty chemicals which are dangerous if they can be easily ignited by brief contact with an ignition source, such as a burning match, and if the flame spreads rapidly.

Flashback. Occurs when flame from a torch burns back into the tip, the torch, or the hose. It is often accompanied by a hissing or squealing sound with a smoky or sharp-pointed flame.

Flashpoint. The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.

Genotoxic and genotoxicity. These apply to agents or processes which alter the structure, information content, or segregation of DNA, including those which cause DNA damage by interfering with normal replication processes, or which in a non-physiological manner (temporarily) alter its replication. Positive genotoxicity test results are usually taken as indicators for mutagenic effects.

Hazard category. The division of criteria within each hazard class, e.g., oral acute toxicity and flammable liquids include four hazard categories. These categories compare hazard severity within a hazard class and should not be taken as a comparison of hazard categories more generally.

Hazard class. The nature of the physical or health hazards, e.g., flammable solid, carcinogen, acute toxicity.

Hazardous chemical. Any chemical which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified.

IARC. International Agency for Research on Cancer, a component of the World Health Organization, located in Lyon, France.

Ignitable. A solid, liquid or compressed gas which is capable of being set afire.

Inhalation. Breathing in of a substance in the form of a gas, vapor, fume, mist, or dust.

Inhibitor - A substance that is added to another to prevent or slow down an unwanted reaction or change.

In Vitro. Outside a living organism (e.g., in a test tube).

Latency Period. The time that elapses between exposure and the first manifestations of disease or illness.

LC50 - Lethal Concentration 50, 50% Lethal Concentration. The concentration of a chemical in air or of a chemical in water which causes the death of 50% (one half) of a group of test animals. The LC50 can be expressed in several ways:

- as parts of material per million parts of air by volume (ppm) for gases and vapors,
- as micrograms of material per liter of air (mg/l), or
- as milligrams of material per cubic meter of air (mg/m3) for dusts and mists, as well as for gases and vapors.

LD50 - Lethal Dose 50. The amount of a chemical, given all at once, which causes the death of 50% (one half) of a group of test animals. The LD50 dose is usually expressed as milligrams or grams of material per kilogram of animal body weight (mg/kg or g/kg).

LEL or LFL - Lower Explosive Limit or Lower Flammable Limit. Lowest concentration of a substance in air (usually expressed in percent by volume) that will produce a flash or fire when an ignition source (heat, electric arc, or flame) is present. At concentrations lower than the LEL, propagation of a flame will not occur in the presence of an ignition source. Also see UEL.

mg/kg. Milligrams of substance per kilogram of body weight, commonly used as an expression of toxicological dose (e.g., 15 mg/kg).

mg/m3. Milligrams per cubic meter; a unit for measuring concentrations of particulates or gases in the air (a weight per unit volume). For example, 20 mg/m3.

Mutation. A permanent change in the amount or structure of the genetic material in a cell. The term "*mutation*" applies both to heritable genetic changes that may be manifested at the phenotypic level and to the underlying DNA modifications when known (including, for example, specific base pair changes and chromosomal translocations). The terms "*mutagenic*" and "*mutagen"* are used for agents giving rise to an increased occurrence of mutations in populations of cells and/or organisms.

NFPA. The National Fire Protection Association is an international membership organization which promotes fire protection and prevention and establishes safeguards against loss of life and property by fire.

NIOSH. The National Institute for Occupational Safety and Health is a part of the Centers for Disease Control and Prevention, U.S. Public Health Service, U.S. Department of Health and Human Services.

Odor Threshold. The lowest concentration of a substance in air that can be detected by smell.

PEL - Permissible Exposure Limit. A legally enforceable occupational exposure limit established by OSHA, usually measured as an eight-hour time-weighted average, but also may be expressed as a ceiling concentration exposure limit.

Personal Protective Equipment (PPE)- Any devices or clothing worn by the worker to protect against hazards in the environment. Examples are respirators, gloves, safety glasses.

Precursor Chemical. Chemicals used in the course of legitimate research that can potentially be used in the illicit production of Controlled Substances such as methamphetamine, cocaine, heroin, and MDMA (ecstasy).

ppm. Parts per million; the proportion (by volume) of a gas or vapor per million parts of air; also the concentration of a chemical in a liquid or solid form.

Reproductive toxicity. This hazard includes *adverse effects on sexual function and fertility* in adult males and females, as well as *adverse effects on development of the offspring*. Some reproductive toxic effects cannot be clearly assigned to either impairment of sexual function and fertility or to developmental toxicity. Nonetheless, chemicals with these effects shall be classified as reproductive toxicants.

- ***Adverse effects on sexual function and fertility.*** Any effect of chemicals that interferes with reproductive ability or sexual capacity. This includes, but is not limited to, alterations to the female and male reproductive system, adverse effects on onset of puberty, gamete production and transport, reproductive cycle normality, sexual behavior, fertility, parturition, pregnancy outcomes, premature reproductive senescence, or modifications in other functions that are dependent on the integrity of the reproductive systems.

Adverse effects on development of the offspring*.* Any effect of chemicals which interferes with normal development of the conceptus either before or after birth, which is induced during pregnancy or results from parental exposure. These effects can be manifested at any point in the life span of the organism. The major manifestations of developmental toxicity include death of the developing organism, structural abnormality, altered growth and functional deficiency.

Respiratory sensitizer. A chemical that will lead to hypersensitivity of the airways following inhalation of the chemical.

Self-accelerating decomposition temperature (SADT). The lowest temperature at which self-accelerating decomposition may occur with a substance as packaged.

Self-heating chemical. A solid or liquid chemical, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is liable to self-heat; this chemical differs from a pyrophoric liquid or solid in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days).

- Self-heating of a substance or mixture is a process where the gradual reaction of that substance or mixture with oxygen (in air) generates heat. If the rate of heat production exceeds the rate of heat loss, then the temperature of the substance or mixture will rise which, after an induction time, may lead to self-ignition and combustion.

Self-reactive chemicals. Thermally unstable liquid or solid chemicals liable to undergo a strongly exothermic decomposition even without participation of oxygen (air).

Serious eye damage. The production of tissue damage in the eye, or serious physical decay of vision, following application of a test substance to the anterior surface of the eye, which is not fully reversible within 21 days of application.

Skin corrosion. The production of irreversible damage to the skin; namely, visible necrosis through the epidermis and into the dermis, following the application of a test substance for up to 4 hours. Corrosive reactions are typified by ulcers, bleeding, bloody scabs, and, by the end of observation at 14 days, by discoloration due to blanching of the skin, complete areas of alopecia (baldness), and scars. Histopathology should be considered to evaluate questionable lesions.

Skin irritation. The production of reversible damage to the skin following the application of a test substance for up to 4 hours.

Skin sensitizer. A chemical that will lead to an allergic response following skin contact.

Specific target organ toxicity - single exposure (STOT-SE). Specific, non-lethal target organ toxicity arising from a single exposure to a chemical. All significant health effects that can impair function, both reversible and irreversible, immediate and/or delayed.

Specific target organ toxicity - repeated exposure (STOT-RE). Specific target organ toxicity arising from repeated exposure to a substance or mixture. All significant health effects that can impair function, both reversible and irreversible, immediate and/or delayed.

STEL. Short-Term Exposure Limit (ACGIH terminology); see TLV.

Target Organ. An organ on which a substance exerts a toxic effect.

Teratogen. A substance that can cause malformations or alterations in the appearance or function of a developing embryo.

TLV - Threshold Limit Value. The occupational exposure limit published by the American Conference of Governmental Industrial Hygienists (ACGIH). ACGIH expresses Threshold Limit Values in four ways:

- **TLV-TWA: The allowable Time-Weighted Average -** A concentration for a normal 8-hour workday or 40-hour workweek.
- **TLV-STEL: Short-Term Exposure Limit -** A maximum concentration for a continuous 15-minute exposure period (maximum of four such periods per day, with at least 60 minutes between exposure periods, and provided the daily TLV-TWA is not exceeded).
- **TLV-C - Ceiling limit -** A concentration that should not be exceeded even instantaneously.
- **TLV-Skin -** The skin designation refers to the potential contribution to the overall exposure by the cutaneous route, including mucous membranes and the eye. Exposure can be either by airborne or direct contact with the substance. This designation indicates that appropriate measures should be taken to prevent skin absorption.

Toxic Substance. Any substance that can cause injury or illness, or which is suspected of being able to cause injury or illness under some conditions.

Toxicity. A relative property of a chemical agent that refers to a harmful effect on some biological mechanism and the conditions under which this effect occurs.

Toxicology. The study of the harmful interactions of chemicals on living organisms and biological systems.

TWA. Time-Weighted Average; the concentration of a material to which a person is exposed, averaged over the total exposure time – generally the total workday (8 to 12 hours); also see TLV.

UEL or UFL. Upper explosive limit or upper flammable limit; the highest concentration of a vapor or gas (highest percentage of the substance in air) that will produce a flash of fire when an ignition source (e.g., heat, arc, or flame) is present. At higher concentrations, the mixture is too "rich" to burn. Also see LEL.

Unstable. Decomposing readily or another unwanted chemical change during normal handling or storage.

Vapor density. The weight of a vapor or gas compared to the weight of an equal volume of air is an expression of the density of the vapor or gas. Materials lighter than air (e.g., acetylene, methane, hydrogen) have vapor densities less than 1.0. Materials heavier than air (e.g., propane, hydrogen sulfide, and ethane) have vapor densities greater than 1.0. All vapors and gases will mix with air, but the lighter materials will tend to rise and dissipate (unless confined). Heavier vapors and gases are likely to concentrate in low places along or under floors, in sumps, sewers, manholes, trenches, and ditches, where they may create fire or health hazards.

Vapor pressure. Pressure exerted by a saturated vapor above its liquid in a closed container. Three facts are important to remember:

- Vapor pressure of a substance at 100° F will always be higher than the vapor pressure of the substance at 68° F (20° C),
- Vapor pressures reported on SDSs in millimeters of mercury (mmHg) are usually very low pressures; 760 mmHg is equivalent to 14.7 pounds per square inch (psi).
- The lower the boiling point of a substance, the higher its vapor pressure.

Volatility. The tendency or ability of a liquid or solid material to form a gas at ordinary temperatures. Liquids such as alcohol and gasoline, because of their tendency to evaporate rapidly, are called volatile liquids.

Training Acknowledgment Form

Name		UOS ID#		Building/Lab No.	
Department		College			

I hereby acknowledge that I have received the appropriate training on the below marked topics to work safely in the lab. I have read and understood the training contents.

I also agree to follow all safety practices and procedures that were addressed in the training to keep University of Sharjah a safe and healthy work environment.

	Topic	Date Completed	Signature
☐	**I. Online safety training courses**		
	II. Emergency Plan including:		
☐	1. Evacuation Plan		
☐	2. Location of Emergency Assembly Points		
☐	3. Fire Action		
☐	4. Gas Leak Action		
☐	5. Chemical/Biological Spill Action		
☐	6. Electric Shock Action		
☐	7. Medical Emergency		
☐	8. Location and use of Fire Extinguishers		
☐	9. Location and use of eye wash & emergency Shower		
☐	10. Emergency Numbers at UOS		
☐	**III. CL Safety Policies and Procedures**		
☐	**IV. Your Role and Responsibilities**		
☐	**V. Chemical Hygiene Plan**		

Any other specific training for the lab related activities- Please List:

1- The training records should be kept by the person in charge for all lab workers.
2- The CL Safety Training (Online Safety Training, Safety Manual, Emergency Response Guide, Emergency and Safety Instructions Poster, and Chemical Hygiene Plan) are available on CL Safety Website.
3- For questions or comments please contact Central Labs Safety Officers (Ahmed, Ext# 3428 and Rizwan, Ext: 3416)

The Central Laboratories Directorate جامعة الشارقة UNIVERSITY OF SHARJAH **إدارة المختبـــــرات المــركــزيـــــة**

Risk Assessment Form

Date: ....

Staff Name: .... Lab No.: .... College: ....

Phone: .... Building No.: .... Department: ....

Category	No.	Hazard/Activity	Who Might be Harmed?	Risk/ Possible Harm	Existing Control Measures to Reduce Risk	Risk Rating			Recommended Control Measures (Further action needed to reduce risks)	Responsible Person	Target Date	Completion Date
						Consequence	Likelihood	Risk Rating				
Chemical Activities	1	Use of hazardous chemicals	Lab staff, students, cleaners	Can cause fires, explosions, skin and eye irritation, cancer, ill health and other serious injuries	*Safety Data Sheets are available for each chemical and the associated hazards of each chemical has been identified *Adequate ventilation is provided (Fume Hood) *All chemicals are used, stored and disposed of in accordance with the Safety Data Sheet or supplier recommendations *Eye, skin and respiratory protection is provided and worn where appropriate and in accordance with the safety data sheet	5	1	Moderate	*Inventory of all chemicals used in the workplace should be prepared	Ahmed	05-12-2017	12-12-2017
	2											

Standard Operating Procedure

For ______________________________

This Template is part of UOS Chemical Hygiene Plan (Appendix# 4) and should be filled by Lab Staff/Lab Faculty Member who is the most knowledgeable and involved in the experimental procedures before carrying out any high risk experiment/research (i.e. working with restricted/highly hazardous chemicals).

SOP Information			
Building No./Lab No.		**Date of the SOP**	
Department		**College**	
Written by		**UOS ID No.**	
Approved by		**UOS ID No.**	
Applies to	All faculty, staff, students working with this procedures		

1. Process or Experiment Description:

Description of the process or experiment that the SOP covers. This may be described in
**general procedure, such as. Generic procedure of specific chemical or class of chemicals with similar hazards (e.g. peroxides, organic azides, mineral acids), Generic procedure that covers several chemicals (e.g. distillation process), Working with Lasers, etc.*
**Specific procedure, synthesis of specific Nanomaterial.*

2. Risk Assessment “Review CL risk assessment form and guide on CL Safety Portal”

2.1 Identify Hazards: Identify potential hazards(chemical, physical, equipment, electrical, lasers, etc.)

2.2 Potential risks: Describe the possible harm

2.3 Control of Hazards: Decide on the controls to mitigate the risks.

2.3.1 Engineering Controls: i.e. Ventilation

2.3.2 Administrative controls

2.3.2.1 Special Handling Procedures and Storage Requirements

2.3.2.2 Training Requirements

2.3.2.3 Prior Approval: Identify any tasks that require prior approval by the incharge person and Why?

2.3.3 Personal Protective Equipment

3. Step-By-Step Operating Procedure: Provide a sequential description of work

4. Waste Disposal: What waste products are likely to be produced and how will they be disposed of?

5. Emergency Procedures

5.1 Emergency Equipment

5.2 Spill and Accident Procedures: What steps will be performed if any of the chemicals used are spilled

5.3 Decontamination Procedures: Describe specific cleanup procedures for work areas and lab equipment that must be performed after completion of your process or experiment.

5.4 First Aid Procedures

6. Documentation of Training on the SOP

Prior to conducting any work with the above process/experiment, the lab/project/research incharge must provide training to his/her laboratory personnel specific to the hazards and procedures involved in working with this process/experiment.

The lab/project/research incharge must provide his/her laboratory personnel with a copy of this SOP and a copy of the SDS for all hazardous chemicals.

I have read and understand the above SOP. I agree to fully adhere to its requirements.

No.	Name	UOS ID#	Signature	Date

Revision History

Revision	Date	Description	Reviewed by	Approved by

8.5 Appendix 5: Hazardous Waste List Form

Hazardous Waste List

Date: ....

Lab No.: .... Building No.: .... College: ....

Lab Incharge: .... Phone: .... Department: ....

No	Item's Name	UOM	Qty	Chemicals Waste				Biohazard Waste			State		
				Nature				Nature					
				Flammable	Corrosive	Toxic	Other Plz. Mention	Highly Infectious Group (A)	Infectious Group (C& E)	Sharps Group (B)	Solid	Liquid	Mixed
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

ATTACH MSDS FOR Chemical Waste

*** UOM "Unit of Measure" - e.g. Box, Bag, Bottle, Litres, ml, Kgs, gms,...etc.**

Please mark nature & state appropriately with an "X"

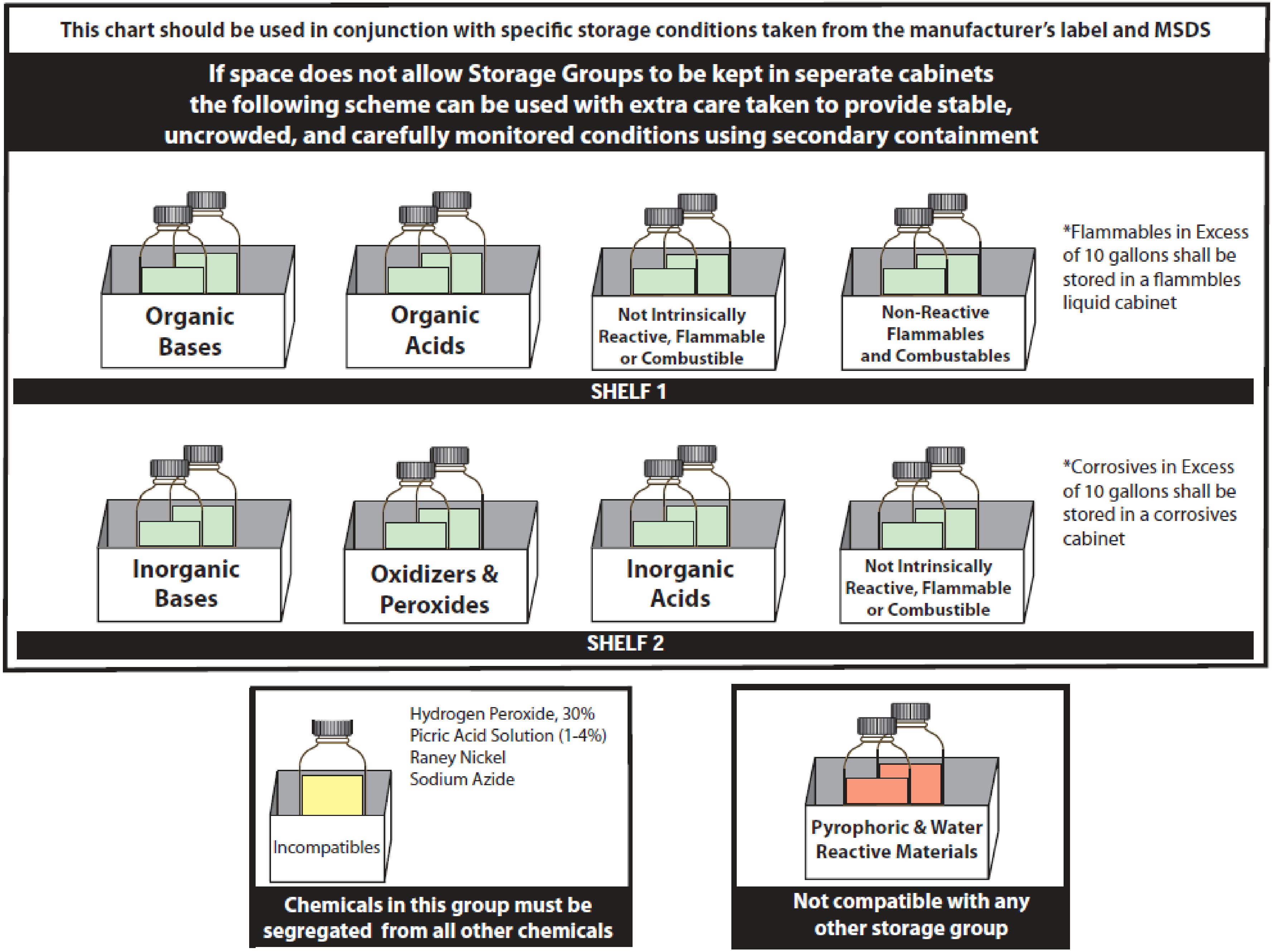
8.6 Appendix 6: Chemical Segregation and Storage Guide

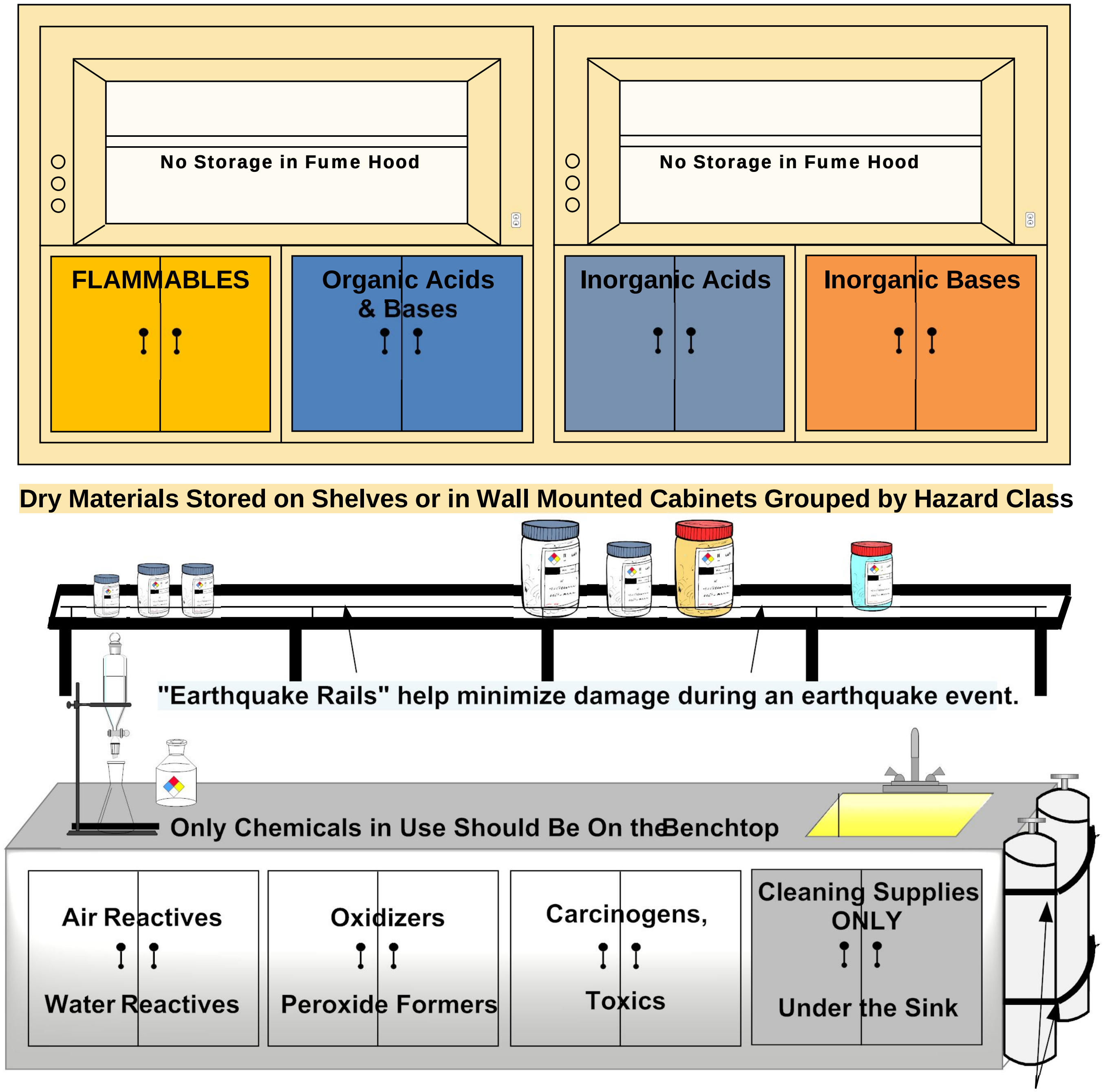
Chemical Segregation and Storage Guide

CLASS OF CHEMICALS and STORAGE GROUP *	RECOMMENDED STORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE MSDS IN ALL CASES
Compressed Gases - Flammable	Store in a cool, dry area, away from oxidizing gases. Securely strap or chain cylinders to a wall or bench top.	Methane, Acetylene, Propane	Oxidizing and toxic compressed gases, oxidizing solids.
Compressed Gases - Oxidizing	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench top.	Oxygen, Chlorine, Bromine	Flammable gases.
Compressed Gases – Poisonous	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench top.	Carbon monoxide, Hydrogen sulfide	Flammable and/or oxidizing gases.
Corrosives – Acids INORGANIC	Store in a separate, lined/protected acid storage cabinet. **DO NOT store acids on metal shelves**	**Inorganic (mineral) acids -** Hydrochloric acid, Sulfuric acid, Chromic acid, Nitric acid.	Flammable liquids, flammable solids, bases, and oxidizers. **Organic acids**
Corrosives – Acids ORGANIC	Store in a separate, lined/protected acid storage cabinet. **DO NOT store acids on metal shelves**	**Organic acids -** Acetic acid, Trichloroacetic acid, Lactic acid	Flammable liquids, flammable solids, bases, and oxidizers. **Inorganic acids**
Corrosives – Bases	Store in a separate storage cabinet.	Ammonium hydroxide, Potassium hydroxide, Sodium hydroxide	Flammable liquids, oxidizers, poisons, and acids.
Explosives	Store in a secure location away from all other chemicals. Do not store in an area where they can fall.	Ammonium Nitrate, Nitro Urea, Sodium azide, Trinitroaniline, Trinitroanisole, Trinitrobenzene, Trinitrophenol/Picric acid, Trinitrotoluene (TNT).	All other chemicals.
Flammable Liquids	Store in a flammable storage cabinet. **Peroxide forming chemicals must be dated upon opening e.g. Ether, Tetrohydrofuran **	Acetone, Benzene, Diethyl ether, Methanol, Ethanol, Hexanes, Toluene	Acids, bases, oxidizers, and poisons.
Flammable Solids	Store in a separate dry cool area away from oxidizers, corrosives.	Phosphorus, Carbon, Charcoal	Acids, bases, oxidizers, and poisons.
Water Reactive Chemicals	Store in a dry, cool location. Protect from water and the fire sprinkler system, if applicable. Label location - WATER REACTIVE CHEMICALS	Sodium metal, Potassium metal, Lithium metal, Lithium Aluminium hydride	Separate from all aqueous solutions, and oxidizers.
Oxidizers	Store in a spill tray inside a non-combustible cabinet, separate from flammable and combustible materials.	Sodium hypochlorite, Benzoyl peroxide, Potassium permanganate, Potassium chlorate, Potassium dichromate. The following are generally considered oxidizing substances: Peroxides, Perchlorates, Chlorates, Nitrates, Bromates, Superoxides	Separate from reducing agents, flammables, and combustibles and organic materials.
Poisons/Toxic	Store separately in a vented, cool, dry, area in chemically resistant secondary containers.	Cyanides, heavy metal compounds, i.e. Cadmium, Mercury, Osmium	Flammable liquids, acids, bases, and oxidizers.
General Chemicals -Non-Reactive	Store on general laboratory benches or shelving.	Agar, Sodium chloride, Sodium bicarbonate, and most non-reactive salts	See MSDS

The segregation chart shown above shall be used at all times. Instances may exist where available storage space is limited and best storage practices may not be used. In those instances, refer to the next pages for alternative storage options.

Chemical Segregation and Storage Chart





Gas Cylinders Securely Chained Preferably With Double Chains on the top and bottom 1/3

Examples:

Flammables: Ethanol, Xylene, Benzene, Methanol, Acetone
Organic Acids: Propionic, Trichloroacetic, Acetic Anhydride
Organic Bases: Hydroxlyamine, Triethylamine, Phenylhydrazine
Inorganic Acids: Hydrochloric, Sulfuric, Stannous Chloride
Inorganic Bases: Sodium Hydroxide, Hydrazine, Potassium Hydroxide
Air Reactives: Titanium Tetrachloride, Red Phosphorus
Water Reactives: Lithium, Sodium, Potassium, White Phosphorous
Oxidizers: Nitric Acid, Permanganates, Peroxides, Chlorates, Nitrites
Peroxide Formers: Isopropyl Ether, Diethyl Ether, Tetrahydrofuran, Dioxane
Carcinogens: Chloroform, Methylene Chloride, Formaldehyde
Toxics: Arsenicals, Cyanides, Methyl Mercaptan
Pyrophorics: t-butyl Lithium, Silane

NTRC NANOTECHNOLOGY RESEARCH CENTER
National Institute for Occupational Safety and Health

Controlling Health Hazards When Working with Nanomaterials: Questions to Ask Before You Start

Here are some questions you should ask yourself before starting work with nanomaterials.	Here are some options you can use to reduce exposures to nanomaterials in the workplace. These options correspond with the questions on the left.		
(1) FORM Have you done a job hazard analysis? What is the physical form of the nanomaterial? How much are you using? Can you reduce exposure to the nanomaterial by changing its form (for example, putting powder into a solution) or reducing the amount you are using?	**DRY POWDER** (typically highest potential for exposure)	**SUSPENDED IN LIQUID**	**PHYSICALLY BOUND/ ENCAPSULATED** (typically lowest potential for exposure)
(2) WORK ACTIVITY How are you using the nanomaterial? Could the work activity cause exposure? Is the likelihood of exposure low or high? Can you change the way you do the activity to reduce the exposure?	**Applies to Dry Powder Nanomaterials** • Higher potential for exposure: Dumping bags of powder, bagging or sieving of products • Lower potential for exposure: Scooping/weighing of product, transporting containers with light surface contamination or closed barrels/bottles/bags	**Applies to Nanomaterial Suspended in Liquids** • Higher potential for exposure: Spraying, open top sonication, producing a mist • Lower potential for exposure: Cleaning up a spill, pipetting small amounts, brushing	**Applies to Physically Bound/Encapsulated Nanomaterial** • Higher potential for exposure: Cutting, grinding, sanding, drilling, abrasive blasting, thermal release • Lower potential for exposure: Manual cutting and sanding, painting with a roller or brush
(3) ENGINEERING CONTROLS Based on the form and the work activity, what engineering controls will be effective? What are the key design and operational requirements for the control? How does the non-nanomaterial base material or liquid affect exposure?	**Applies to Dry Powder Nanomaterials** • Chemical fume hood • Glove box • Nanomaterial handling enclosure • Ventilated bagging or dumping stations • High-efficiency particulate air (HEPA)-filtered local exhaust ventilation	**Applies to Nanomaterial Suspended in Liquids** • Chemical fume hood • Glove box • Nanomaterial handling enclosure • Local exhaust ventilation • Ventilated spray booth	**Applies to Physically Bound/Encapsulated Nanomaterial** • Chemical fume hood • Glove box • Local exhaust ventilation • Downdraft table • Wet cutting/machining • Ventilated tool shroud • Blasting cabinet
(4) ADMINISTRATIVE CONTROLS Have you considered the role of administrative controls? Have you set up a plan for waste management? Have you considered what to do in case of a spill or how you will maintain equipment?	**Applies to All Nanomaterial Forms** • Establish a chemical hygiene plan • Perform routine housekeeping • Train workers • Use signs and labels • Restrict access to areas where nanomaterials are used	• Handle and dispose of all waste materials (including cleaning materials/gloves) in compliance with all applicable federal, state, and local regulations • Use sealed/closed bags or containers, and secondary containment • Label containers, such as "contains nanoscale titanium dioxide"	• Wet wipe or use a HEPA-filtered vacuum • Do not dry sweep or use compressed air • Incorporate nanomaterial safety into existing programs such as hazard communication
(5) PERSONAL PROTECTIVE EQUIPMENT If the measures above do not effectively control the hazard, what personal protective equipment can be used? Have you considered personal protective equipment for the non-nanomaterial base material or liquid?	**Applies to All Nanomaterial Forms** • Nitrile or chemical resistant gloves • Lab coat or coveralls • Safety glasses, goggles, or face shield	• Respiratory protection when indicated and engineering controls cannot control exposures, and in accordance with federal regulations (29 CFR 1910.134) • NIOSH guidance on respirators can be found at www.cdc.gov/niosh/topics/respirators/	• Use personal protective equipment during spill cleanups and equipment maintenance

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

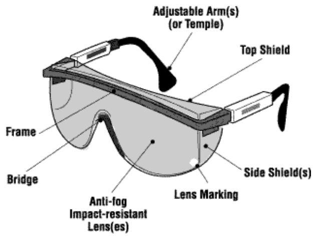
Are you interested in learning more about how you can safely work with nanomaterials or want to stay up-to-date on nanotechnology safety? See the NIOSH NTRC website for more information and links to guidance documents: www.cdc.gov/niosh/topics/nanotech/

DHHS (NIOSH) Publication No. 2018-103 | February 2018
https://doi.org/10.26616/NIOSHPUB2018103

8.8 Appendix 8: Personal Protective Equipment Selection Guide

Applicable PPE	Specific type (example)	Characteristics	Applications
Light latex, vinyl or nitrile gloves	**Disposable latex gloves**	Powdered or un-powdered	Working with biological hazards (known or potentially known infectious materials including work with animals)
	Disposable nitrile gloves 	Puncture, abrasion resistant, protection from splash hazards	Working with biological hazards and chemical splash hazards
	Disposable vinyl gloves	Economical, durable, similar to latex	Working with biological hazards
Light chemical resistant gloves	**Natural rubber latex** 	Chemical resistant, liquid-proof	Working with small volumes of corrosive liquids, organic solvents, flammable organic compounds
Light to heavy chemical resistant gloves	**Nitrile gloves** 	Chemical resistant, good puncture, cut, and abrasion resistance	Apparatus under pressure, air or water reactive chemicals
Heavy chemical resistant gloves	**Butyl gloves** 	High permeation resistance to most chemicals	Large volumes of organic solvents, small to large volumes of dangerous solvents, acutely toxic or hazardous materials
	Viton® II gloves 	High permeation resistance to most chemicals	Same as butyl gloves, plus hazardous material spills
Heavy chemical resistant gloves (cont.)	**Butyl/Silver Shield gloves and apron** 	Extra chemical and mechanical protection	Same as butyl and Viton II gloves, added mechanical protection, hazardous material spills
Insulated gloves	**Terrycloth autoclave gloves**	Heat resistant	Working with hot liquids and equipment, open flames, water bath, oil bath

			
	Cryogen gloves 	Water resistant or water proof, protection against ultra-cold temperatures	Cryogenic liquids handling
Wire mesh gloves		Cut resistant	Working with live animals
Chemical resistant apron	**Rubber-coated wash apron** 	Chemical splash protection, good abrasion resistance	Working with apparatus under pressure, air or water reactive chemicals, large volumes of corrosive liquids
	Neoprene apron and sleeves 	Chemical resistant, tear resistant; splash protection	Water or air reactive chemicals, large volumes of corrosive liquids, small to large volumes of acutely toxic corrosives
Lab Coats	**Knee length lab coats** 	Protects skin and clothing from dirt, inks, non-hazardous chemicals, biohazards without aerosol exposure	General use; Chemical, Biological, Radiation, and Physical Hazards
	Flame resistant lab coat 	Flame resistant (e.g. Nomex or flame-resistant cotton)	Working with water or air reactive chemicals, large volumes of organic solvents, potentially explosive chemicals
	Disposable gowns 	Clothing and skin protection	Working with biohazards

Gowns	**Tyvek gowns** 	High tear resistance, protection from particulates	Working with biohazards with potential for exposure to airborne transmissible disease
Cap	**Bouffant caps** 	Economical protection for hygienic work environments; protection from dirt, dust	Working with biohazards, especially in animal facilities
Shoe Cover	**Disposable shoe covers** 	Protection from dirt, dust; maintenance of hygienic work environments. Adjustable fit, non-skid soles	Working with biohazards, especially in animal facilities
Safety glasses		Polycarbonate lens, side shields for eye protection; meets ANSI and OSHA specifications	**Working with chemical, biological, radiation, physical hazards; laboratory work**
Goggles	**Tight fitting goggles** 	Tight fitting, protects eyes from impact, spray, paint, chemicals, flying chips, dust particles; polycarbonate lens, indirect ventilation, meets ANSI and OSHA specifications	**Working with large volumes of corrosive liquids, small to large volumes of acutely toxic corrosives; working with large volumes of organic solvents, acutely toxic or hazardous chemicals, apparatus under pressure, air or water reactive chemicals**
	Laser Goggles 	Appropriately shaded goggles; optical density based on beam parameters	**Working with Class 3 or Class 4 lasers**
Face shield		Chemical resistant face shield	**For use with mild acids, caustics, aromatic hydrocarbons, methylene chloride; splash hazard; air or water reactive or potentially explosive chemicals**

Safety shield		Acrylic, weighted shield, three sided, benchtop shield, frosted edges	**Protects from chemical splash, beta radiation, exposure to bloodborne pathogens**
Respirators	**Surgical masks** 	Used for bacterial filtration	Working with live animals; working with infectious material with potential aerosol exposure
	N-95 	Protects against dusts, fumes, mists, microorganisms	Working with live animals or infectious materials with known airborne transmissible disease; dusty environments
	Half face 	Air purifying respirator protects against variety of particulates, vapors, dust, mists, fumes; depends on filter cartridge used	Working with live animals or infectious materials with known airborne transmissible disease; dusty environments; chemical vapors; particulates
	Full face 	Same as half- face, but with greater protection factor, and greater protection of eyes and face; depends on filter cartridge used	Working with live animals or infectious materials with known airborne transmissible disease; dusty environments; chemical vapors; particulates
	PAPR 	Air supplying respirator; delivers steady supply of filtered air with loose fitting hoods	Working in BSL – 3 environments; working in dusty environments; chemical vapors, particulates; used when full-face or half –face respirator doesn't fit individual

8.9 Appendix 9: Packaging Requirements for Wekaya

Wekaya' s Health-Care Waste Management Program (Packaging Requirements)

Type of Waste		Description	Packaging/Labeling	Color of Tag
Highly Infectious Waste (Group A) (Waste MUST be sterilized or chemically treated (Sodium Hypochlorite; prior to collection Wekaya)*		Waste contaminated with; contagious pathogens ➢ Waste foam Isolation wards ➢ Research laboratories ➢ Tissues, (Swabs), equipment that has been in contact with infected patients ➢ Excreta	➢ Autoclavable bag(PP) ➢ Red ➢ Fill Level=65%	Red
Infectious Waste (Group C and E)		All waste that came in contact with human blood or fluids is considered as infectious waste. ➢ Pathological Waste ➢ Anatomical Waste ➢ Human Tissue ➢ Used gloves, aprons, masks, shoe and head covers, dressings, bandages, cotton balls, peripads, diapers, cotton swabs, etc.	➢ LDPE bag ➢ Yellow ➢ Thickness = 100 microns ➢ Fill level = 65%	Yellow
Sharps (Group B)		➢ Needles, infusion sets, scalpels, knives, blades ➢ Broken glass, etc.	➢ HDPE yellow Container ➢ Leak Proof ➢ Fill Level= Max. 75%	Orange
Chemical Waste/Pharmaceuticals Group D	Chemical Waste/ (Large quantities of chemical waste should be returned to supplier.)	Small quantities of chemical waste: ➢ Chemicals are to be accepted ONLY in original container. ➢ Laboratory reagents, film developer, disinfectants, Solvents, etc.	➢ Inform Wekaya regarding type and quantity. ➢ Send MSDS. ➢ Hold chemical safely until further instructions.	Blue
	Pharmaceuticals	➢ Pharmaceuticals that are expired or no longer needed, except cytotoxic pharmaceuticals.	➢ LDPE bag ➢ Yellow ➢ Thickness = 100 microns ➢ Fill level = 65%	Blue
	Wastes with high content of heavy metals	➢ Batteries, broken thermometers, blood-pressure gauges, etc.	➢ Same as Pharmaceuticals, but Label clearly as Heavy Metals	Blue
	Cytotoxic Waste	➢ Expired or no longer needed cytotoxic pharmaceuticals are to be returned to supplier. ➢ Any waste contaminated with cytotoxic products, including excreta from patients like faces, vomit, urine, etc.	➢ Same as Pharmaceuticals, but label clearly as cytotoxic waste.	Blue
Radioactive Waste (Group F)		➢ To be returned to the supplier.	➢ Box made of Lead	-
Municipal Waste		Aerosols , Domestic Waste, Food Waste, Paper towels for hand washing, paper packaging materials, materials used to clean-up decontaminated or nonhazardous spills.	➢ Black Bag	-
Based on: Cabinet resolution 37 for the year 2001 "System for the circulation and use of hazardous materials, dangerous and medical waste". *WHO				

8.10 Appendix 10: Peroxide Forming Chemicals

Peroxide Forming Chemicals

Autoxidation in common laboratory solvents can lead to unstable and potentially explosive peroxide formation. The reaction can be initiated by exposure to air, heat, light, or contaminants. Most of these solvents are available with inhibitors to slow the peroxide formation. Examples of inhibitors include BHT (2,6-di-tert-butyl-4-methyl phenol) and Hydroquinone. There are three categories of peroxide formers:

Class A - Severe Peroxide Hazard: chemicals are those which form explosive levels of peroxides after prolonged storage, especially after exposure to air without concentration. Test these for peroxide formation before using and discard **3 months** after opening.

Class A Chemicals		
Butadiene (liquid monomer)	Chloroprene (liquid monomer)	Divinylacetylene
Isopropyl ether	Tetrafluoroethylene (liquid monomer)	Vinylidine chloride
Potassium amide	Potassium metal	Sodium amide

Class B- Concentration Hazard: chemicals form peroxides that are hazardous only on concentration by distillation or evaporation. Test these before distillation and discard after **12 months**.

Class B Chemicals		
Acetal	Dicyclopentadiene	Methyl isobutyl ketone
Acetaldehyde	Diethyl ether	4-Methyl-2-pentanol
Benzyl alcohol	Diethylene glycol dimethyl ether	2-Pentanol
2-Butanol	Dioxane	4-Penten-1-ol
Cumene	Ethylene glycol dimethyl ether	1-Phenylethanol
Cyclohexanol	4-Heptanol	2-Phenylethanol
2-cyclohexen-1-ol	2-Hexanol	2-Propanol
Cyclohexene	Methylacetylene	Tetrahydrofuran
Decahydronaphthalene	3-Methyl-1-butanol	Tetrahydronaphthalene
Diacetylene	Methylcyclopentane	Vinyl ether

Class C- Shock and Heat Sensitive: chemicals consist of monomers which form peroxides that can initiate explosive polymerization. The peroxides formed in these reactions are extremely shock- and heat-sensitive. Inhibited monomers should be tested before use and discarded after **12 months**. Uninhibited monomers should be discarded 24 hours after opening.

Class C Chemicals		
Acrylic acid	Styrene	Chlorotrifluoroethylene
Acrylonitrile	Tetrafluoroethylene (gas)	Methyl methacrylate
Butadiene (gas)	Vinyl acetate	Vinyl chloride
Chloroprene (gas)	Vinyl acetylene	Vinyl pyridine

Precautions for Peroxide Forming Chemicals

All labs should actively manage peroxide-forming chemicals and follow the following practices:

1. Date all peroxidizables upon receipt and opening. Unless the manufacturer has added an inhibitor, materials should be disposed of in a timely manner.
2. Periodically test contents for peroxides using peroxide test strips; record test date and results on container. A common test used is the MQuant™ Peroxide Test Strip (0-100 ppm range). Available through Sigma Aldrich Catalog # 1100810001. If the test results are:

< 25 ppm	Considered safe for general use
25-100 ppm	Not recommended for distilling or otherwise concentrating
>100 ppm	Avoid handling and contact CLD for proper disposal

3. Do not open any container with evidence of peroxide formation such as obvious crystal formation around the lid or in the liquid, or visible discoloration.
4. Keep peroxide-forming chemicals in their original containers to minimize conditions that accelerate peroxide formation.
5. All peroxide forming solvents should be tested prior to distillation.
6. Other precautions are similar to those used for flammables.

Emergency Numbers  أرقام الطـــوارئ

UOS Security — الأمن الجامعي

050 586 8063 (24h)

Ext No. 3024

Ambulance — إسعاف الجامعة

050 527 2233 (Women)

050 161 9365 (Men)

Maintenance Department — إدارة الصيانة

Ext No. 5555 (06 505 1555)

Electricity (Saheb)	**050 547 8423**	الكهرباء (صاحب)
Maintenance (Ehab)	**055 788 0509**	الصيانة (إيهاب)
AC (Aabid Ali)	**052 948 6110**	التكييف (عابد على)

Safety Office — مكتب السلامة
Central Labs — المختبرات المركزية

Ahmed	**Ext No. 3428, 050 105 6540**	احمد
Rizwan	**Ext No. 3416, 055 708 9239**	رضوان

Civil Defense — الدفاع المدني

997

University City Police — شرطة المدينة الجامعية

06 505 9555

Police **999** الشرطة

Tank Cleaning Schedule at the University of sharjah

SN	LOCATION	BLDG.	CAPACITY	QTY.	DAYS	DATE OF CLEANING
1	**Villas Al Khawarizmi**	A to I Block	15,000	2	DONE	October 20-26, 2018
		F21 to F32	10,000	1		
		F21 to F32	1,000	6		
		Mosque	1,000	1		
		Nursery	5,000 & 1,000	2		
2	**Villas Al Zahrawi**	Blocks J, K, L, M	10,000	2	DONE	October 20-26, 2018
		Blocks S, T, U, V, W	10,000	2		
		Blocks S, T, U, V, W	2,000	20		
		R - Block	5,000	1		
		R - Block	1,000	6		
3	**Villas - Al Beyruni**	Up to F-Block	20,000	1	DONE	October 20-26, 2018
		K9 to K32	2,500	9		
		N1 to N12	2,500	4		
		M1 to M12	2,500	4		
4	**Villas Ibn Khaldoun**	Blocks N, O, P, Q	1,000	40	DONE	October 20-26, 2018
		Blocks N, O, P, Q	5,000	40		
		Chanc. Villa	2,000	2		
1	**Girls Hostels**	W13 Admin	1,000 (2)	2	2 DAYS	January 26-27, 2019
		W13A	10,000 (1) & 1,000 (5)	6		
		W13B	10,000 (1) & 2,000 (4)	5		
		W13C	10,000 (2) & 1,000 (20)	22		
		W13D	10,000 (2) & 1,000 (20)	22		
		W13E	10,000 (2) & 1,000 (20)	22		
		W13F	10,000 (2) & 1,000 (20)	22		
		W13G	10,000 (1) & 2,000 (2)	3		
		W13H	10,000 (1) & 2,000 (2)	3		
		W14	5,000 (1) & 2,000 (1)	2		
2	**Boys Hostels**	M13A	10,000 (1) & 1,000 (5)	6	2 DAYS	January 28-29, 2019
		M13B	10,000 (1) & 2,000 (4)	5		
		M13C	10,000 (2) & 1,000 (20)	22		
		M13D	10,000 (2) & 1,000 (20)	22		
		M13E	10,000 (2) & 1,000 (20)	22		
		M14	50,000 (1) & 1,000 (1)	2		
3	**Medical Hostel**	Block A, B, C, D, E, F (Ground)	7,920	6	2 DAYS	January 29-30, 2019
		Block A, B, C, D, E, F (Roof)	4,752	6		

		Block G & H (Roof)	1,056 (5)	10		
		Block G & H (Ground)	88,074	2		
4	**Medical College**	M25	20,000	2	2 DAYS	January 30-31, 2019
		M28	20,000	1		
		M31	20,000	1		
		M32	20,000	2		

Carla Mae Esperida

Assistant Operations Manager

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INTER EMIRATES BUILDING CLEANING SERVICES

UNIVERSITY OF SHARJAH- PERIODIC CLEANING

S.NO	Cleaning Job	Daily	Weekly	Monthly	Quarterly	Yearly
1	Reception and Entrance Lobby Sweep and Mop Clean	x				
2	Damp Dust All Furniture	x				
3	Clean the toilet with Disnifectant	x				
4	Entrance Glass Cleaning	x				
5	Buff the floor with Machine	x				
6	Vacuum clean the Carpet Area	x				
7	Dust Clean vertical blinds, bookcases, Cabinets & Lockers	x				
8	Remove all Garbage in office labs, classrooms and Prayer Rooms.	x				
9	Toilet general cleaning		x			
10	Clean and all the external pillar, walls, floor and ramp		x			
11	Wash and buff all the floor, stair & lifts		x			
12	Clean all the kitchen cabinet and refrigerators		x			
13	Entrance glass cleaning		x			
14	Villa corridors clean and wash		x			
15	waste bin sanitization		x			
16	Scrubbing and buffing classroom			x		
17	Carpet Shampooing carpet area			x		
18	Window glass cleaning			x		
19	Lobby area and corridors deep cleaning			x		
20	External glass cleaning				x	
21	Roof top cleaning				x	
22	Periodic cleaning to external glazing & facades					x
23	All the classrooms and corridors General cleaning & floor polishing					x
24	All the dorm corridors, window and room deep cleaning					x

25	Villa Cleaning	**Upon Request**	**Upon Request**	**Upon Request**	**Upon Request**	**x**

WATER MANAGEMENT POLICY AND PROCEDURE

1. Water Conservation Program Implementation

1.2. Details of program:

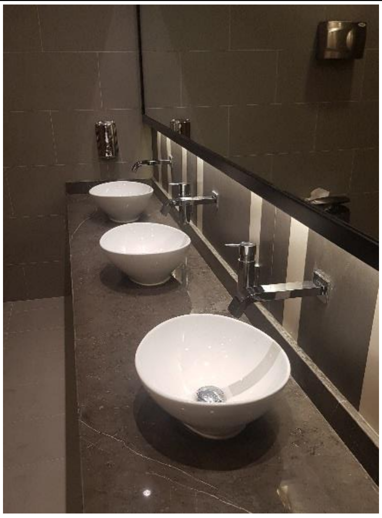
The University of Sharjah is located in hot climate arid zone with permeable sand (desert) all around, thus the traditional water conservation methods such as ponds for rainwater harvesting etc. are not practicable. Therefore, the University implements water conservation through various actions, briefly mentioned below:

The University has completely shifted to use faucet aerators and/or automatic faucets in all academic buildings; introduction of low flush/dual flush toilets is also under implementation.

Green spaces throughout the university are irrigated with treated wastewater and with the use of water efficient irrigation systems such as drip and sprinkler systems.

On campus water is also conserved through reusing treated grey water in selected locations, water quality monitoring and preservation to conserve water for its intended use, promoting water less car wash on the campus grounds, as well as disseminating knowledge and awareness to the university community and beyond through various programs and initiatives for water conservation and environmental protection.

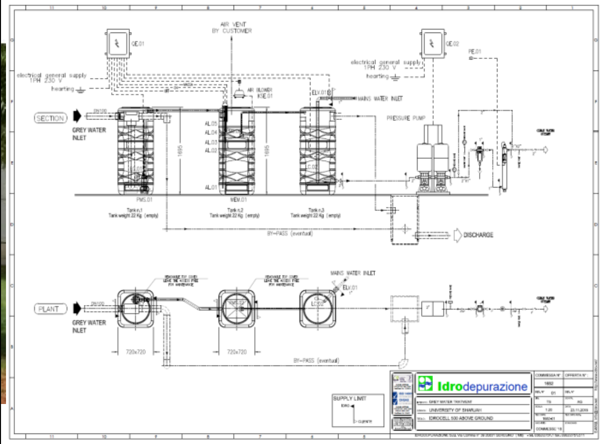
[> 25-50% of water consumption was conserved]

	
Faucet aerators/automatic faucets in all academic buildings (Photo source: University of Sharjah)	

Low flush/dual flush toilets
(Photo source: University of Sharjah)

WATER MANAGEMENT POLICY AND PROCEDURE

Reuse of treated wastewater for irrigation
(Photo source: University of Sharjah)



Reuse of treated grey water (Photo source: Tanks of greywater recycling system in the student dormitory, and Construction drawing of installed greywater recycling system, University of Sharjah)

WATER MANAGEMENT POLICY AND PROCEDURE

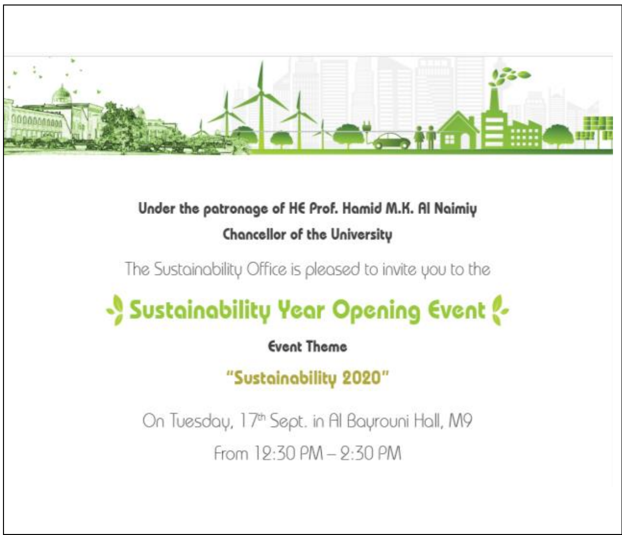
Use of Water efficient irrigation systems (sprinklers and drip irrigation)
(Photo source: University of Sharjah)

Water less car wash on the campus grounds
(Photo source: University of Sharjah)

BEFORE

AFTER

Water quality preservation to conserve water for its intended use
(Photo source: University of Sharjah)



Awareness programs and initiatives for water conservation and environmental protection
(Photo source: University of Sharjah)

WATER MANAGEMENT POLICY AND PROCEDURE

2. Water Recycling Program Implementation

2.1 Wastewater collection, treatment and recycling

[> 50% water is recycled]

Details of the program:

The sewage produced within campus is collected using suction system and water tankers (if necessary), and delivered to a nearby wastewater treatment plant. Because the water resources are scarce, and the City of Sharjah depends mostly on the costly desalination of seawater and/or treated ground water, the vast areas of green space on the University campus is completely irrigated by the treated wastewater pumped through a dedicated irrigation network.

Layout of University City Wastewater Treatment Plant that treats waste water of University of Sharjah

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UNIVERSITY OF SHARJAH

WATER MANAGEMENT POLICY AND PROCEDURE

Views of primary clarifier of University City Wastewater Treatment Plant

Top Primary (left) and Secondary Right) clarifier of University City Wastewater Treatment Plant

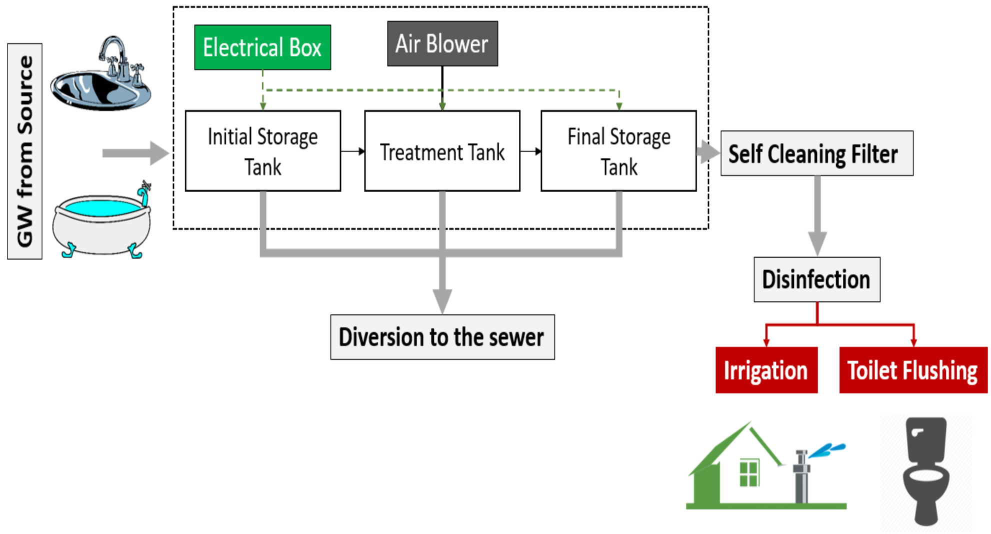
Disinfection and storage facilities of University City Wastewater Treatment Plant

Treated waste water irrigating the plants and trees

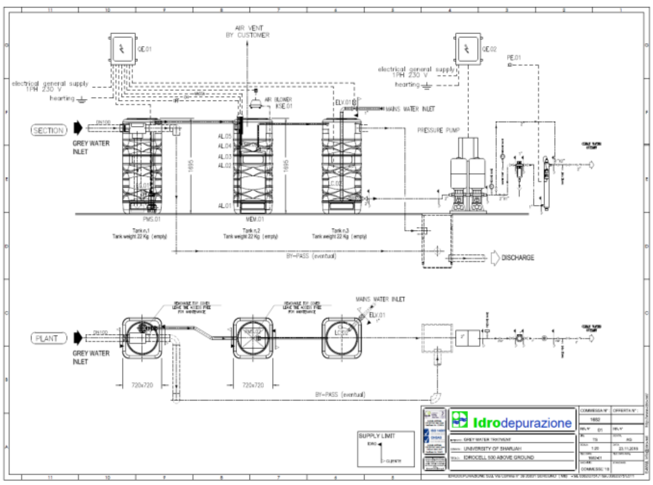
2.2 Greywater Recycling

Details of the program:

Instead of sending water to treatment plant after single use, the University is encouraging the reuse of greywater for toilet flushing & irrigation. Greywater reuse provides an unconventional water supply alternative that can help reduce the demand for conventional/fresh water. In this project, greywater reuse for toilet flushing is implemented in the students' dormitory in University of Sharjah.



Schematic diagram of grey water recycling system (Example: University of Sharjah)



Construction drawing of greywater recycling system installed in the University (Example: University of Sharjah)

Tanks of greywater recycling system in the student dormitory (Example: University of Sharjah)

Schematic diagram of recycling system (Example: University of Sharjah)

Picture of a shower room in student dormitory whose water is supplied to grey water system (Example: University of Sharjah)

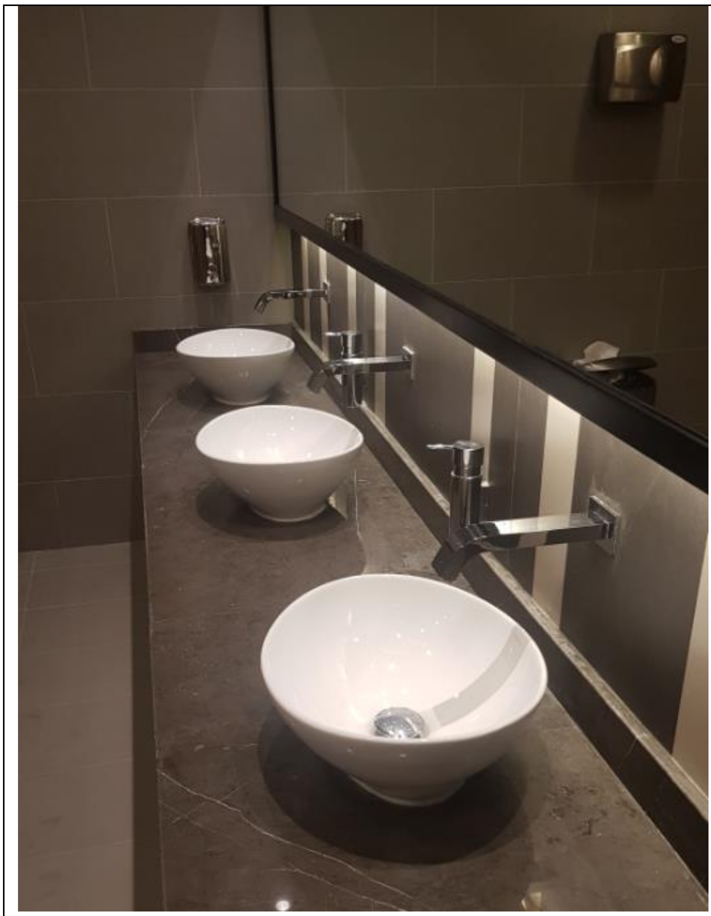
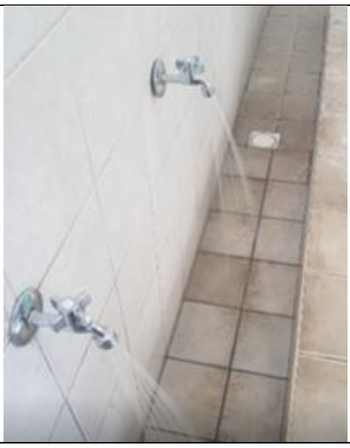
3. The Use of Water Efficient Appliances (Water tap, toilet flush, etc)

[> 50% water efficient appliances installed]

Details of program:

The University of Sharjah has recently phased out all water non-efficient taps and replaced them with either automatic type taps or installed faucet aerators to reduce water wastage.
Irrigation of green spaces, plants, and flowers throughout the University is carried out by efficient irrigation systems such as drip irrigation and sprinkler irrigation systems.

	
Example of efficient water faucet (automatic type) (Photo source: University of Sharjah)	Example of efficient water faucet (low flow type) (Photo source: University of Sharjah)

	
Example of efficient water faucet (automatic type) (Photo source: University of Sharjah)	Example of efficient water faucet (low flow type) (Photo source: University of Sharjah)
	
Example of efficient water faucet (automatic type) in ablution area (Photo source: University of Sharjah)	Example of efficient water faucet (low flow type) in ablution area (Photo source: University of Sharjah)

Example of the dual flush low flow toilet (Photo source: University of Sharjah)

Examples of efficient drip irrigation network (Photo source: University of Sharjah). Plants and flowers in the University are irrigated with a vast drip irrigation system.

Examples of efficient sprinkler irrigation system (Photo source: University of Sharjah). Green spaces of the university are irrigated with a vast modern sprinkler system

Installation of Smart water meters (Photo source: University of Sharjah) to monitor the use, detect leaks and conserve water

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UNIVERSITY OF SHARJAH

Central Laboratories Directorate

Chemical Hygiene Plan

January 2019
CLD/SS/CHP
Revision 00

Acknowledgement

The Central Laboratories Directorate would like to thank below staff members who helped prepare and finalize Chemical Hygiene Plan for University of Sharjah.

- Dr. Hamadeh Tarazi - Lecturer, College of Pharmacy
- Mr. Ahmed Hassanein- Sr. Safety Officer
- Mrs. Nemat Dek Al-Bab- Team Leader of Chemistry Labs Unit, College of Sciences
- Mr. Jobi Joseph- Lab Supervisor, Sharjah Institute for Medical Research

Special thanks to the Laboratory Safety Committee formed by Chancellor's Decision No. 51 for the Academic Year 2018/2019 for reviewing and approving the Chemical Hygiene Plan.

- Eng. Mahmoud Abu Shammeh- Director of Central Labs.
- Dr. Ihsan Ahmed Shehadi- Chair of Chemistry Department, College of Science.
- Dr. Mohammad Harb Semreen- Chair of Medicinal Chemistry Department, College of Pharmacy.
- Dr. Farah Al-Marzooq- Post-Doctoral Research Associate, Sharjah Institute for Medical Research.
- Ms. Racha El Khoury- Lecturer, Applied Biology Department, College of Science.
- Engr. Louay Al Maleh- Director of Facilities Management and Planning Department.
- Mr. Osama Taqatqa- Radiation Safety Officer, College of Engineering.
- Mr. Ahmed Hassanein- Sr. Safety Officer, Central Laboratories Directorate
- Mr. Rizwan Ali- Safety Officer, Central Laboratories Directorate

	Prepared By	Reviewed By	Approved By
Name	Central Laboratories Directorate	Laboratory Safety Committee	Dr. Hussein EL Mehdi
Designation	Director, Central Laboratories Directorate	Committee members	Dean, Academic Support Services
Signature		As per approved meeting minutes no.2 for 2018-2019	
Date	24.01.2019		27/1/19

Revision History					
Revision	Date	Description	Prepared By	Reviewed By	Approved By
00	27-1-2019	First Issue	Central Labs Directorate	Lab Safety Committee	Dean of Academic Support Services

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1.0 Introduction

Laboratories are potentially dangerous places. Chemical and physical hazards are present and a lack of knowledge or a moment's inattention could lead to an injury, illness, death or property damage. To reduce the likelihood of laboratory accidents and to achieve the University of Sharjah Commitment to provide a safe laboratory environment for faculty, staff and students, the Central Labs Directorate has developed a general Chemical Hygiene Plan (CHP). The plan includes a set of safety policies and procedures that protect workers from the health and physical hazards associated with the hazardous chemicals used in the University of Sharjah Labs.

Each laboratory using hazardous chemicals is required to have a copy of the CHP readily available to all laboratory personnel. Each laboratory worker must be familiar with the contents of the CHP and the procedures for obtaining additional safety information needed to perform their duties safely. The softcopy of this plan is available on the Cl Safety Portal and the hard copies will also be located in the individual labs.

This CHP will be regularly reviewed and updated with inputs, comments, and suggestions from UOS faculty and staff. Suggestions for the improvement of this document are welcomed, please contact CLD.

1.1 Purpose

The purpose of this CHP is to define safe work practices and procedures to help ensure that faculty, staff and students are protected from the health and physical hazards associated with the handling, storage and use of hazardous chemicals in University laboratories and to comply with the University of Sharjah Internal Audit Office Requirements.

1.2 Scope and applicability

The CHP applies to all laboratories and laboratory personnel at the University of Sharjah that use, store, or handle hazardous chemicals.

This generic Chemical Hygiene Plan was written to fulfill uniform requirements applicable to most University labs. It is not intended to be all-inclusive. It cannot address specific chemical handling procedures for all chemicals but describes general protective guidelines for working with hazardous chemicals in laboratories.

Departments, individual labs or research groups engaged in work with potentially hazardous chemicals that have unusual characteristics, or not covered in this CHP, must customize the document by adding additional sections addressing the hazards and how to mitigate their risks, as appropriate.

Laboratory personnel include faculty, staff, research associates and assistants, technicians, teaching assistants, post-doctoral fellows, graduate and undergraduate students must read, understand and comply with the CHP prior to work with hazardous chemicals in laboratories.

A written record stating that each laboratory worker has reviewed the Chemical Hygiene Plan and related health and safety training shall be kept by the person in charge of the lab. See Appendix 2 for a copy of this document.

1.3 Roles and responsibilities

1.3.1 College Deans, Chairs of Departments and Director of Central Labs

1. Responsible and accountable for the environmental, health and safety performance of their colleges / departments.
2. Ensures that the Central Labs health and safety policy and procedures, and Chemical Hygiene Plan are adhered and implemented.
3. Ensures provision of adequate budget and resources for EHS management as and when needed.
4. Ensures provision of EHS information, training and supervision.
5. Shut down the lab in case of serious violations which may cause severe consequences.
6. Ensures compliance with applicable legal requirements related to labs and relevant activities.

1.3.2 Lab Staff/Lab Faculty Member

Lab Staff: (Lab Supervisors, Lab Officers, Lab Engineers, Clinical Tutors, Lab Technicians and research assistant)

Lab Faculty Member: (Professor, Associate Professor, Assistant Professor, Lecturer and Researchers)

1. Complies with the Central Labs health and safety policy and procedures, the recommended safe work practices, Central Labs safety instructions and UOS Chemical Hygiene Plan.
2. Ensures that personnel working in laboratories know and follows the guidelines and requirements contained within the Laboratory Safety Manual, policies and procedures.
3. Ensures that personnel working in laboratories are familiar with the contents and location of the lab safety manual, policies and procedures, emergency response guide and all emergency response equipment such as fire extinguisher, eyewash and emergency showers, etc.
4. Reports immediately about malfunctioning of lab equipment, including protective equipment such as fume hoods, biological safety cabinets, safety showers and fire extinguishers to the central labs directorate for immediate action.
5. Holds the primary responsibility for ensuring that all laboratory work is done safely avoiding incidents.
6. Ensures availability of proper PPE and they are in good working condition. Also ensures all laboratory personnel have received the appropriate training on the selection and use of proper PPE and they use it when working in laboratories under their supervision.
7. Plans and conducts each activity / operation / experiment with taking in considerations best safety practices and risk associated with each activity.
8. Carry out a risk assessment prior to the lab operations and if required, ensure risk control measures are in place.
9. Ensures laboratories under supervision are maintained in a clean and orderly manner, and personnel working in the lab practice good housekeeping.
10. Restricts access of visitors and children to areas under their supervision when potential health and physical hazards exist, with the exception of university approved activity e.g., tours, school visits, etc.
11. Ensures that all safety measures for unattended operations / experiments are evaluated to avoid any incidents that may happen.

12. Ensures that staff and students under supervision are provided with adequate training and information specific to the hazards found within respective laboratories on how to work safely with these hazards. Note: Hazards may include; Chemical, Biological, Radiological, Mechanical, Electrical, and other health and physical hazards.
13. Keeps updated chemical and / or Biological inventories in the lab and stores chemicals according to compatibility.
14. Ensures that Safety Data Sheets (SDS) are accessible for all chemicals and Biological in use or stored.
15. Performs monthly self-inspection for the lab(s) under control and consults with the safety staff when safety questions or concerns arise.
16. Ensures cleaning of any chemical or biological spill that may happen.
17. Ensures safe handling, storage and disposal of hazardous waste.
18. Attends health and safety training.
19. Faculty are required to provide all lab students with the proper links to all safety documents through the blackboard system and enforce them to read it.
20. Stop any activity that may cause harm to the Human life/ Assets/ Environment…etc.
21. Completes any corrective action assigned during a lab safety inspection before the due date.
22. Ensure those contractors are properly supervised during installation process to avoid any incidents.
23. Reports any incident immediately to the DCLD or LSO using "Incident Report".
24. Ensures compliance with applicable legal requirements related to labs and relevant activities.

1.3.3 Lab Team Leader

1. Complies with the Central Labs health and safety policy and procedures, the recommended safe work practices, Central Labs safety instructions and UOS Chemical Hygiene Plan.
2. Ensures that lab staff under your supervision complies with the Central Labs health and safety policy and procedures, the recommended safe work practices and Central Labs safety instructions.
3. Inspect and Monitor labs under your supervision regularly and report any violation to Chair of Department.
4. Ensures that lab staff under your supervision completes any corrective action assigned during a lab safety inspection before the due date.
5. Stop any activity that may cause harm to the Human life/ Assets/ Environment…etc. and report to Chair of Department.
6. Ensures lab staff under your supervision are attending health and safety training.
7. Ensures lab staff under your supervision are reporting the incidents immediately to DCLD or LSO
8. Ensure lab staff under your supervision are carrying out monthly self-lab safety inspection for their labs.
9. Ensures compliance with applicable legal requirements related to labs and relevant activities.

1.3.4 Laboratory Safety Committee

1. Reviews the safety measures and procedures implemented in Central Labs and suggest improvements.
2. Develops new policies and procedures regarding laboratory safety as required.
3. Ensures that local safety regulations, requirements and standards are met.
4. Reviews, develops, updates and approves manuals, procedures and emergency response plans issued by the Central Labs Directorate.
5. Reviews and approves training programs.
6. Reviews inspection reports, incident reports internal and external laboratories audit and develop corrective strategies where needed.
7. Investigates lab related incidents that may happen and report violations to the top management.

1.3.5 Central Labs Safety Officer

1. Complies with the Central Labs health and safety policy and procedures.
2. Facilitates the implementation of CLD Policies and procedures, Chemical Hygiene Plan and assist in establishing a safe work environment by collaborating with the lab supervisor, faculty and lab personnel.
3. Conducts periodic and un-announced laboratory inspections of all Central labs facilities to verify lab safety checklist and report any safety issues to the Central Labs director and chair of department.
4. Provides advice to relevant personnel on the implementation of CLD policies and procedures as and when needed.
5. Provides all appropriate and required personal protective equipment PPE to laboratory personnel based on their request.
6. Coordinates for buying safety supplies and equipment required for the central labs.
7. Manages the collection and disposal of hazardous waste.
8. Reviews laboratory incidents reports and recommends appropriate corrective actions when required.
9. Stop any activity that may cause harm to the Human life/ Assets/ Environment…etc, and report to DCLD.
10. Ensures compliance with applicable legal requirements related to labs and relevant activities.

1.3.6 Central Labs Maintenance Section

1. Ensure that all lab equipment/machines are properly installed and placed safely according to manufacturer recommendations, and maintain the relevant records.
2. Ensures lab staff are appropriately trained on newly installed equipment and all relevant safety instructions and maintain the training records.
3. Develop Preventive Maintenance Plan for emergency and safety equipment such as safety shower and eyewash station, fume hoods, Biological safety cabinets…etc. and other lab equipment/machines which required regular maintenance and perform the maintenance accordingly.
4. Check regularly the LPG system and compressed gas cylinders for any issues and take corrective actions accordingly.
5. Respond immediately to any lab equipment maintenance request.

6. Ensure those contractors are properly supervised during installation process to avoid any incidents.

1.3.7 Students

1. Complies with the Central Labs health and safety policy and procedures, the recommended safe work practices, Central Labs safety instructions and UOS Chemical Hygiene Plan.
2. Wears the appropriate personal protective equipment when present in the lab and when conducting work with hazardous materials or operations.
3. Familiarizes with the location of emergency equipment and emergency response plans.
4. Never work alone in the lab, always asks for proper supervision.
5. In case material or equipment is unfamiliar and not trained with it, then Informs the supervisor before working with such material and equipment.
6. Report any unsafe conditions or incidents to the lab staff immediately
7. Ensures compliance with applicable legal requirements related to labs and relevant activities.

2.0 Chemical Management

2.1 Chemical Procurement and Receiving

1. Only the minimum amount of the chemical needed to perform the planned work should be ordered. Preferably for one academic year.
2. Where possible, substitute highly hazardous chemicals with less hazardous chemicals.
3. Only containers with proper labels identifying the chemical and its hazard should be accepted.
4. Shipments with breakage or leakage should be refused.
5. Proper protective equipment and handling and storage procedures should be in place before receiving a shipment.
6. Purchases of high-risk chemicals should be reviewed and approved by the Chair of the Department, with the assistance of Central Labs Safety Section if necessary.
7. Chemical shipments should be dated upon receipt and the inventory should be updated.

2.2 Chemical Storage

1. Chemicals should be separated and stored according to hazard category and compatibility (refer to Appendix 6). Always consult SDS and label information for storage requirements.
2. Maintain existing labels on incoming containers of chemicals and other materials.
3. Peroxide formers should be dated upon receipt, again dated upon opening, and stored away from heat and light with tight-fitting, nonmetal lids.
4. Label all containers of hazardous chemicals (including transfer vessels, beakers, flasks, and process equipment) with the chemical name and hazard warnings.
5. Open shelves used for chemical storage should be secured to the wall.
6. Secondary containment (bin, tray, bucket, basin) should be used for liquids.
7. Keep incompatibles separate during transport, storage, use, and disposal. Consult the SDS
8. Oxidizers and flammables should be stored separately to prevent contact in the event of an accident.
9. Chemicals should not be stored in the chemical fume hood, on the floor, in areas of egress, on the benchtop (except for small amounts of working solutions), near heat sources, or in direct sunlight.
10. Laboratory-grade, flammable-rated refrigerators and freezers should be used to store sealed chemical containers of flammable liquids that require cool storage.
11. Highly hazardous chemicals should be stored in a well-ventilated and secure area designated for that purpose.
12. Storage of more than 10 gallons of flammable and combustible liquids (with a flash point less than 100^{o} F~37.7^{o}C) shall be in an approved flammable liquid storage cabinet.
13. Flammable chemicals should be stored in a spark-free environment and in approved flammable-liquid containers and storage cabinets. Grounding and bonding should be used to prevent static charge buildups when dispensing solvents.
14. Chemical storage and handling rooms should be controlled-access areas. They should have proper ventilation, appropriate signage, and fire suppression systems.

2.3 Chemical Handling

1. A risk assessment should be conducted prior to beginning work with any hazardous chemical for the first time. (see Appendix 3)
2. Read all SDS and label information before using a chemical for the first time, or if it has been awhile since using the chemical.
3. Lab Staff should ensure that proper engineering controls (ventilation) and PPE are in place.
4. Use adequate ventilation (such as a fume hood) when transferring even a small amount of a particularly hazardous chemical.

5. Transfer flammable liquids from 5 gallon containers (or less) to smaller containers only in a laboratory fume hood.

2.4 Chemical Inventory

Prudent management of chemicals in any laboratory is greatly facilitated by keeping an accurate, up-to-date chemical inventory.

1. A current copy of the inventory must be kept in the laboratory. Chemical inventory form is available on the Central Labs Safety Portal.
2. Chemicals that are no longer needed or are waste should be disposed through waste disposal contractor (Wekaya) or given to another lab/department to use them.
3. Compressed gases need to be included in the chemical inventory.

2.5 Chemicals Transporting

1. Uses bottle carriers or carts with secondary containment when transporting chemicals outside of the laboratory or between stores and laboratories.
   a) The carrier or cart will protect glass container from breakage during transportation through hallways.
   b) The carriers and carts are available in Central Labs Store.
2. Makes sure that incompatible chemicals are not transported at the same time.
3. Wear appropriate personal protective equipment (PPE) while transporting chemicals.
4. While transporting chemicals between W12 - M12 buildings, follow the new Central Labs paved pathways.
5. Use unoccupied passenger elevator for transporting chemicals between floors.
6. Never transport chemicals in your personal car as it may cause serious consequences. Always call Central Labs Safety Section for assistance.

2.6 Chemical Waste Management

Hazardous waste is generally defined as waste that is dangerous or potentially harmful to human health or the environment. Every effort should be made to dispose of hazardous waste in a proper, safe, and efficient manner. It is the responsibility of the individual creating the waste to properly identify and manage waste chemicals within the lab prior to pick-up by the waste disposal company “Wekaya”. No chemical waste should be poured down the drain or discarded in the trash unless it is certain that doing so does not violate hazardous waste regulations.

Local and international Hazardous waste regulations and laws:

1. Decision No.5/2011 of Executive Council of the Emirate of Sharjah on healthcare waste management.
2. UAE Federal Law No. 24 of 1999 concerning protection and development of Environment.
3. UAE Cabinet Resolution (Ministerial Order) No. 37 of 2001, "Handling of Hazardous Substances, Hazardous Wastes and Medical Wastes".
4. MOH administrative decision No.79, 2009 on Medical Waste Management
5. Recommendations of World Health Organization (WHO), "Safe Management of Waste from Health-Care Activities
6. Environmental Protection Agency (EPA)

Violations and Fines

According to Decision No. 5/2011 of Executive Council of the Emirate of Sharjah on healthcare management there is a fine of 150,000 AED in case of the below violations:

1. Dumping of Health Care Waste (HCW) in bins which are not assigned for.
2. Dumping into land.

3. Discharging into the sea.

2.6.1 Waste Identification and Labeling

Hazardous Waste Label			
Building-Lab No.			
Lab Staff Name			
	Contents	Hazard	Volume (ml/L)
1			
2			
3			
4			
5			
Comments:			

1. All chemical constituents in a hazardous waste container must be identified by full chemical names (i.e., do not use chemical formulas or abbreviations). Additionally, consult SDSs (specifically Section 2, "Hazard Identification" and Section 13, "Disposal Considerations") to obtain information about hazardous constituents and characteristics.
2. Mixed waste containers must be labeled from the moment waste is added to the container. This will prevent accidental mixing of incompatible chemicals. You can print the CL Hazardous Waste Label and pasted on the container.
3. The label must be completed prior to disposal by Wekaya.
4. Empty containers do not have to be managed as hazardous waste. An exception for this is that empty containers that previously held acutely/extremely hazardous chemicals are considered hazardous waste and must be given to Wekaya for disposal.
5. Sharps waste contaminated with hazardous chemicals must be placed into puncture resistant containers (e.g., sharps container, plastic or metal container with lid) and properly labeled.
6. Batteries such as nickel-cadmium, mercury, silver, lithium, nickel-metal hydride, lead-acid and any other rechargeable batteries are considered hazardous waste but alkaline batteries are not considered hazardous waste and can be discarded in the trash.

2.6.2 Waste Storage Requirements

The following procedures must be followed in order to have hazardous waste safely stored prior to collection by Wekaya:

1. Keep all hazardous materials in appropriate closed containers with airtight lids.
2. Containers must be in good condition and compatible with the waste they contain (no corrosive waste in metal containers).
3. Containers must be kept closed at all times except when adding waste.
4. Containers must be labelled with full chemical names, hazards and exact content.
5. Containers should be segregated by chemical compatibility during storage (e.g., acids away from bases, secondary containment can be used as a means of segregation).
6. Do not mix incompatible chemicals in the same container. (e.g., oxidizers with flammables, acids with bases)
7. Do not store hazardous waste in the fume hood.
8. Do not mix hazardous materials with non-hazardous materials. It greatly increases waste disposal costs.
9. Containers that continually generate hazardous wastes (e.g., HPLC wastes) must be placed in secondary containment, and all tubes and hoses must be closed as much as possible to minimize potential release.
10. Containers must be stored at or near the point of generation (wastes should remain in the same room they were generated in).

2.6.3 Waste Disposal Procedures

To have your hazardous waste picked up by "Wekaya", you must follow the following procedures:

1. Fill the waste list form (Appendix 5) and send it through email as a soft copy with SDSs for all materials to the Medical waste officer in your facility.
2. Follow packaging requirements for Wekaya (Appendix 9)
3. Bring the waste to the collection point as instructed by the medical waste officer.
4. When transporting chemical waste, you must use chemical transport cart or leak proof trolley which is available at Central Labs store.
5. Ensure "Hazardous Waste" label with full chemical names, and volume are clearly displayed on each container.
6. The outside of the containers must be clean and free of chemical contamination.
7. The company will NOT accept unknown waste chemicals or hazardous wastes that have chemical abbreviations or symbols.
8. Medical waste officer will arrange with the company for waste collection from our facilities

Remember

- Do not dispose of chemicals by pouring them down the drain or placing them in the trash.
- Do not use fume hoods to evaporate hazardous chemicals.

2.6.4 Waste Minimization

Waste minimization is any action that reduces the amount of hazardous wastes before they are shipped off-site for disposal and it is very important to protect the environment and also to reduce the disposal costs.

Guidelines for Waste Reduction

1. Order only and store the amount of material needed for the project or experiment. Hazardous waste is often a result of outdated and/or unused chemicals.
2. Substitute hazardous materials with less toxic or non-hazardous compounds, such as using spirit, bi-metal, or digital thermometers instead of mercury thermometers.
3. Using micro or semi-micro techniques in the teaching and research laboratories whenever it is possible.
4. Maintain current chemical inventories and review inventories before purchasing additional chemicals.
5. Before disposing of unwanted, unopened, uncontaminated chemicals check with others in your department or other departments who may be able to use them.
6. Recycling: distill and reuse solvents if possible.

3.0 Hazardous Chemicals Identification and classification

Chemical classification systems are designed to communicate hazards. The three most widely used classification systems are the American Occupational Safety and Health Administration (OSHA) Globally Harmonized System for Classifying and Labeling Chemicals, the National Fire Protection Association (NFPA) system of classifying the severity of hazards, and the Department of Transportation (DOT) hazard classes. These classification systems are used by chemical manufacturers when creating safety data sheets and chemical labels, therefore it is important that lab employees understand the basic elements of each classification system.

3.1.1 Globally Harmonized System for Classifying Chemicals (GHS)

The Globally Harmonized System (GHS) is a world-wide system adopted by OSHA for standardizing and harmonizing the classification and labeling of chemicals. The objectives of the GHS are to:

- Define health, physical, and environmental hazards of chemicals;
- Create classification processes that use available data on chemicals for comparison with the defined hazard criteria (numerical hazard classification is based on a 1 – 5 scale, 1 being the most hazardous and 5 being the least hazardous); and
- Communicate hazard information, as well as protective measures, on labels and Safety Data Sheet (SDS), formerly known as Material Safety Data Sheets (MSDS).

3.1.1.1 Safety Data Sheets (SDSs)

The SDS provides comprehensive information that is essential for the safe handling of hazardous chemicals. Laboratory personnel should use the SDS as a resource to obtain information about hazards and safety precautions. SDSs cannot provide information for hazards in all circumstances. However, the SDS information enables the employees to develop safety control measures such as Standard Operating Procedures (SOPs). The SDS contains 16 headings which are illustrated as following:

1. **Section 1, Identification** includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.
2. **Section 2, Hazard(s) identification** includes all hazards regarding the chemical; required label elements.
3. **Section 3, Composition/information on ingredients** includes information on chemical ingredients; trade secret claims.
4. **Section 4, First-aid measures** includes important symptoms/ effects, acute, delayed; required treatment.
5. **Section 5, Fire-fighting measures** lists suitable extinguishing techniques, equipment; chemical hazards from fire.
6. **Section 6, Accidental release measures** lists emergency procedures; protective equipment; proper methods of containment and cleanup.
7. **Section 7, Handling and storage** lists precautions for safe handling and storage, including incompatibilities.
8. **Section 8, Exposure controls/personal protection** lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).
9. **Section 9, Physical and chemical properties** lists the chemical's characteristics.
10. **Section 10, Stability and reactivity** lists chemical stability and possibility of hazardous reactions.

11. **Section 11, Toxicological information** includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
12. **Section 12, Ecological information**
13. **Section 13, Disposal considerations**
14. **Section 14, Transport information**
15. **Section 15, Regulatory information**
16. **Section 16, Other information,** includes the date of preparation or last revision.

3.1.1.2 Chemical Labeling

The GHS standardized label elements, which are not subject to variation and must appear on the chemical label, contain the following elements:

- Symbols (hazard pictograms) are used to convey health, physical and environmental hazard information, assigned to a GHS hazard class and category;
- Signal Words such as "Danger" (for more severe hazards) or "Warning" (for less severe hazards), are used to emphasize hazards and indicate the relative level of severity of the hazard assigned to a GHS hazard class and category;
- Hazard statements (e.g., "Danger! Extremely Flammable Liquid and Vapor") are standard phrases assigned to a hazard class and category that describe the nature of the hazard; and
- Precautionary statements are recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to the hazardous chemical.

The GHS also standardizes the hazard pictograms that are to be used on all hazard labels and SDSs. There are 9 pictograms that represent several defined hazards, and include the harmonized hazard symbols which are intended to convey specific information about each hazard. The following table illustrates these GHS hazard pictograms.

		
Carcinogen, Respiratory Sensitizer, Reproductive Toxicity, Target Organ Toxicity, Mutagenicity	**Flammable, Pyrophoric, Self- Heating, Emits Flammable Gas, Organic Peroxide**	**Irritant, Dermal Sensitizer, Acute Toxicity (harmful), Narcotic Effects**
		
Gas Under Pressure	**Corrosive**	**Explosive, Organic Peroxide, Self-Reactive**

		
Oxidizer	**Environmental Toxicity**	**Acute Toxicity (Severe)**

GHS Hazard Pictograms

Since most chemicals stored in the laboratory have been purchased from a chemical manufacturer, the GHS labeling and pictogram requirements are very relevant and must be understood by laboratory employees. The below template illustrates the GHS label format showing the required elements.

ACETONE

PRODUCT IDENTIFIER

Code:
Product Name:

SUPPLIER IDENTIFICATION

Company Name:
Address:
Phone Number:

PRECAUTIONARY STATEMENTS

Keep away from heat, sparks, open flames, hot surfaces – No smoking.
Avoid breathing dust, fumes, gas, mist, vapors, and spray.
Repeated exposure may cause skin dryness and cracking.
In Case of Fire: Use water spray, alcohol-resistant foam, dry chemical, or carbon dioxide.
First Aid: Move out of dangerous area. Consult a physician. If inhaled, move person to fresh air. If not breathing, give artificial respiration. In case of skin contact, wash with soap and plenty of water. In case of eye contact, rinse thoroughly with plenty of water for at least 15 minutes. If swallowed, do not induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water, consult a physician.

HAZARD PICTOGRAMS

SIGNAL WORD

Danger

HAZARD STATEMENT

Highly flammable liquid and vapor. Causes mild skin irritation.
Causes serious eye irritation.
May cause drowsiness or dizziness.

GHS Label Format

As mentioned earlier, one of the objectives of GHS was to create a quantitative hazard classification system (numerical hazard classification is based on a 1 – 5 scale, 1 being the most hazardous and 5 being the least hazardous) based on physical characteristics such as flash point, boiling point, lethal dose of 50% of a population, reactivity, etc. the below table illustrates how the numerical hazard classification works for flammable liquids.

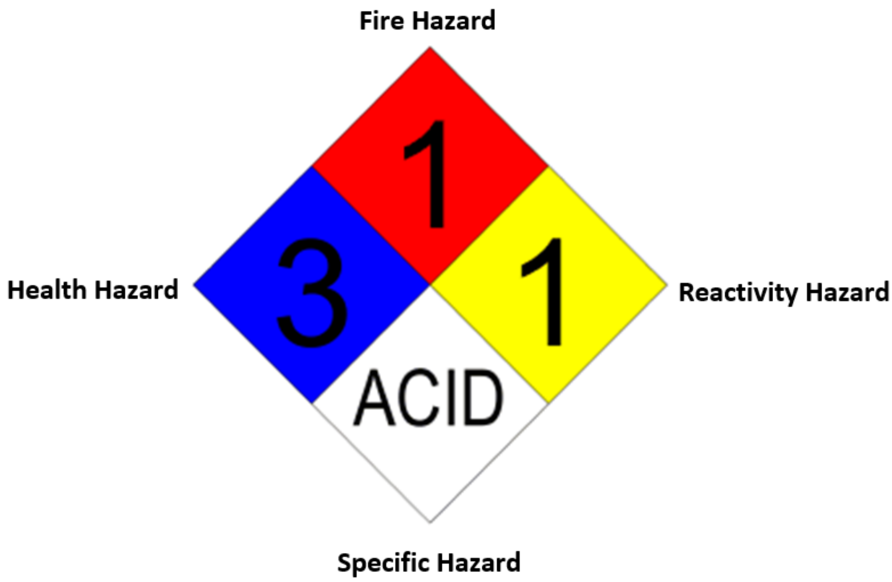
Category	Criteria	Pictogram	Signal Word	Hazard Statement
1	Flash point < 23 °C Boiling point $\leq$ 35 °C		Danger	Extremely flammable liquid and vapor
2	Flash point < 23 °C Boiling point > 35 °C		Danger	Highly flammable liquid and vapor

3	Flash point ≥ 23 °C and < 60 °C		Warning	Flammable liquid and vapor
4	Flash point ≥ 60 °C and ≤ 93 °C		Warning	Combustible liquid
5	There is no Category 5 for flammable liquids			

GHS Hazard Classification System for Flammable Liquids

3.1.2 National Fire Protection Association Rating System

The NFPA system uses a diamond-shaped diagram of symbols and numbers to indicate the degree of hazard associated with a particular chemical. This system was created to easily and quickly communicate hazards to first responders in the event of an emergency situation. These diamond-shaped symbols are placed on chemical containers to identify the degree of hazard associated with the specific chemical or chemical mixture. The NFPA system is a common way to identify chemical hazards and should be understood by laboratory employees. The NFPA 704 numerical rating system is based on a 0 – 4 system; 0 meaning no hazard and 4 meaning the most hazardous (note: this in contrast to the GHS system of 1 –5 where 1 is the most hazardous and 5 is the least hazardous). The below figure illustrates the NFPA hazard rating system and identifies both the hazard categories and hazard rating system.



Health Hazard	Fire Hazard	Reactivity Hazard	Specific Hazard
4 - Deadly	**4** - FP* < 73° F	**4** - May Detonate	**ACID** Acid
3 - Extreme Danger	**3** - FP < 100° F	**3** - Shock/Heat May Detonate	**ALK** Alkali
2 - Hazardous	**2** - 100° F < FP < 200° F	**2** - Violent Chemical Change	**COR** Corrosive
1 - Slightly Hazardous	**1** - FP > 200° F	**1** - Unstable if Heated	**W** No Water
0 – Normal Material	**0** - Will Not Burn	**0** - Stable	 Radioactive
	*** FP = Flash Point**		

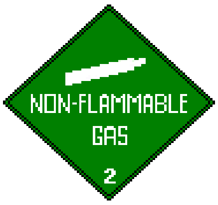
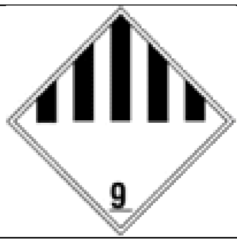
NFPA Hazard Rating System

3.1.3 Department of Transportation Hazard Classes

The DOT regulates the transportation of all hazardous materials, and defines a hazardous material as any substance that has been determined to be capable of posing an unreasonable risk to health, safety, or property when transported in commerce. There are several methods that can be employed to determine whether a chemical is hazardous for transport, a few of which included:

- Reviewing the DOT Hazardous Materials Table
- Reviewing the SDS, specifically Section 2: Hazardous Identification and Section 14: Transport Considerations, for the chemical being shipped.
- Reviewing the chemical label and looking for hazard information.
- Understanding the chemical and physical properties of the chemical.

All hazardous chemicals must be properly labeled by the chemical manufacturer or distributor before transportation occurs. Chemical containers stored in laboratories are not required to be labeled per DOT standards; however, the DOT 9 hazard classes are often seen on chemical containers and are discussed in Section 14 of GHS-formatted SDSs. The DOT 9 hazard classes are illustrated below. It should be noted that the below table only lists the primary hazard classes.

		
DOT Class 1 Explosives	**DOT Class 2 Compressed Gases**	**DOT Class 3 Flammable Liquids**
		
DOT Class 4 Flammable Solids	**DOT Class 5 Oxidizers**	**DOT Class 6 Poisons**
		
DOT Class 7 Radioactive Materials	**DOT Class 8 Corrosives**	**DOT Class 9 Miscellaneous**

DOT Hazard Classes

4.0 Hazardous Chemicals Classes

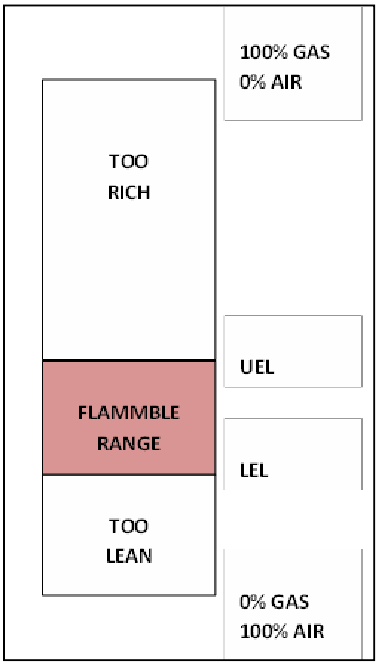
Chemicals can be divided into several different hazard classes. The hazard class provides information to help determine how a chemical can be safely stored and handled. Each chemical container, whether supplied by a chemical manufacturer or produced in the laboratory, must have a label that clearly identifies the chemical constituents. In addition to a specific chemical label, more comprehensive hazard information can be found by referencing the SDS for that chemical. The OSHA Laboratory Standard defines a hazardous chemical as any element, chemical compound, or mixture of elements and/or compounds which is a physical or health hazard. This definition of a hazardous chemical and the GHS primary classes of chemicals are briefly discussed below.

4.1 Physical Hazards

A chemical is a physical hazard if there is scientifically valid evidence that it is flammable, combustible, water reactive, explosive, organic peroxide, oxidizer, pyrophoric, self-heating, self-reactive, or a compressed gas. Each physical hazard is briefly defined below.

4.1.1 Flammable Liquids

Flammable hazards are materials which under standard conditions can generate sufficient vapor to cause a fire in the presence of an ignition source. Flammable liquids (e.g., hexane, ethyl acetate, and xylene) are more hazardous at elevated temperatures due to more rapid vaporization. The following definitions are important to understand when evaluating the hazards of flammable liquids:



- **Flammable liquid** is a liquid having a flash point at or below 93 °C (200 °F).
- **Flash point** is the minimum temperature at which the application of an ignition source causes the vapors of a liquid to ignite under specified test conditions.
- **Boiling point** is the temperature at which the vapor pressure of a liquid equals the atmospheric pressure and the liquid changes into a vapor.
- **Auto ignition temperature** is the minimum temperature at which self-sustained combustion will occur in the absence of an ignition source.
- **Lower explosive limit (LEL)** is the lowest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat).
- **Upper explosive limit (UEL)** is the highest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat).

Some organic solvents (e.g., diethyl ether) have the potential to form potentially shock- sensitive organic peroxides. See **Appendix 10** for additional information regarding peroxide forming chemicals.

Flammable Liquids Storage

The following guidelines for storing flammable liquids must be followed in all laboratories:

1. Stored away from ignition sources such as open flames, smoking materials, hot surfaces,

sparks from welding or cutting, operation of electrical equipment, and static electricity.

2. Flammable and combustible liquids should be stored in flammable storage cabinets whenever possible. No more than 10 gallons of flammable liquid is permitted to be stored outside of a flammable storage cabinet unless it is stored in a flammable safety can equipped with a spring-loaded lid and an internal screen as shown.

3. Domestic refrigerators or freezers must never be used to store flammable liquids. Flammable liquids can only be stored in refrigerators or freezers that are designed for flammable materials (Note: most refrigerators and freezers are not intended for flammable storage).
4. Flammable liquids must be stored in well-ventilated areas free from ignition sources.
5. Some organic solvents (e.g., diethyl ether, tetrahydrofuran) have a shelf-life and can form organic peroxides over time while in storage. These “peroxide formers” must be dated when received from the chemical manufacturer and disposed of once expired. If any time-sensitive chemicals are found to be past the manufacturer’s expiration date, they must be submitted to Central Labs Safety Section for hazardous waste disposal immediately. See Appendix 10 for a list of commonly found organic solvents that potentially form organic peroxides.

4.1.2 Flammable Solids

A flammable solid is a solid which is readily combustible, or may cause or contribute to a fire through friction. Readily combustible solids are powdered, granular, or pasty substances which are dangerous if they can be easily ignited by brief contact with an ignition source. Flammable solids are more hazardous when widely dispersed in a confined space (e.g., finely divided metal powders).

4.1.3 Pyrophoric, Self-Heating, and Self-Reactive Materials

Pyrophoric material (also called “spontaneously combustible”) is a liquid or solid that even in small quantities and without an external ignition source can ignite after coming in contact with the air.

Self-heating material is a solid or liquid, other than a pyrophoric substance, which, by reaction with air and without energy supply, is liable to self-heat. This endpoint differs from a pyrophoric substance in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days).

Self-reactive material is a thermally unstable liquid or solid liable to undergo a strongly exothermic thermal decomposition even without participation of oxygen (air).

4.1.4 Water-Reactive Materials

A water-reactive material is a liquid or solid that reacts violently with water to produce a flammable or toxic gas, or other hazardous conditions. Alkali metals (e.g., sodium, potassium) and metal hydrides (e.g., calcium hydride) are common water-reactive materials found in laboratories.

Reactive Materials Storage

The following guidelines for storing reactive materials must be followed in all laboratories:

1. The amount of reactive materials stored in the lab must be kept to a minimum. Any expired or unnecessary reactive materials must be properly disposed of as hazardous

waste.

2. All reactive materials must be clearly labeled with the original manufacturer's label, which should have the chemical name, hazard labels, and pictograms. The label should not be defaced in any way.
3. All reactive materials should be placed into secondary containment as a best management practice.
4. Suitable storage locations for reactive materials include inert gas-filled desiccators or glove boxes, flammable storage cabinets that do not contain aqueous or other incompatible chemicals, or intrinsically safe refrigerators or freezers that also do not contain aqueous or other incompatible chemicals. If possible, store all reactive chemicals in a small flammable cabinet (such as a cabinet underneath a fume hood) dedicated only for reactives. Signs should be posted to indicate their presence and unique hazards.
5. Many reactive materials are water and/or air reactive and can spontaneously ignite on contact with air and/or water. Therefore, reactives must be handled under an inert atmosphere and in such a way that rigorously excludes air and moisture.
6. If reactive materials are received in a specially designed shipping, storage, or dispensing container (such as the Aldrich Sure-Seal packaging system), ensure that the integrity of that container is maintained. Ensure that sufficient protective solvent, oil, kerosene, or inert gas remains in the container while reactive materials are stored.

4.1.5 Oxidizers

An oxidizing solid/liquid is a solid/liquid which, while in itself is not necessarily combustible, may generally by yielding oxygen, cause or contribute to the combustion of other material. Hydrogen peroxide, nitric acid, and nitrate solutions are examples of oxidizing liquids commonly found in a laboratory. Sodium nitrate, Sodium perchlorate, and Potassium permanganate are examples of oxidizing solids commonly found in a laboratory.

4.1.6 Organic Peroxides

An organic peroxide is an organic liquid or solid which contains the bivalent -O-O- structure and may be considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. The term also includes organic peroxide formulations (mixtures). Such substances and mixtures may:

- Be liable to explosive decomposition;
- Burn rapidly;
- Be sensitive to impact or friction; or
- React dangerously with other substances

Oxidizers and Organic Peroxide Storage

The following guidelines for storing oxidizers and organic peroxides must be followed in all laboratories:

1. Oxidizers (e.g., hydrogen peroxide, sodium nitrate) and organic peroxides (e.g., methyl ethyl ketone peroxide, benzoyl peroxide) must be stored in a cool, dry location and kept away from combustible materials such as wood, pressboard, paper, and organic chemicals (e.g., organic solvents and organic acids).
2. If possible, store all strong oxidizing agents in a chemical cabinet dedicated only for oxidizers.
3. The amount of oxidizers and organic peroxides stored in the lab should be kept at a

minimum.
4. Peroxide forming solvents should be sealed tightly and stored away from light and heat.
5. All material must be clearly labeled; the original manufacturer's label with the chemical name, hazard labels, and pictograms should not be defaced or covered.

4.1.7 Explosives

An explosive substance (or mixture) is a solid or liquid substance (or mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed that can cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gases. A pyrotechnic substance (or mixture) is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative, self-sustaining, exothermic chemical reactions. An explosive compound that is sometimes found in a laboratory setting is picric acid (2,4,6-trinitrophenol).

4.1.8 Gases under Pressure

The Globally Harmonized System (GHS) of classification and labeling of chemicals defines "Gases under Pressure" as gases that are contained in a receptacle at a pressure not less than 280 kPA at 20 °C or as a refrigerated liquid.

The GHS has four groups for gases under pressure:

- **Compressed gas** is a gas which when packaged under pressure is entirely gaseous at -50 °C; including all gases with a critical temperature ≤ -50 °C.

  The critical temperature is the temperature above which a pure gas cannot be liquefied, regardless of the degree of compression.
- **Liquefied gas** is a gas which when packaged under pressure is partially liquid at temperatures above -50 °C.
- **Refrigerated liquefied gas** is a gas which when packaged is made partially liquid because of its low temperature.
- **Dissolved gas** is a gas which when packaged under pressure is dissolved in a liquid phase solvent.

All compressed gases are hazardous and present both a physical and a health hazard due to the fact they are stored in compressed cylinders, which can explode and act as a projectile if ruptured. Compressed gases also carry the hazards of the chemicals they contain such as asphyxiation (carbon dioxide), toxicity (nitric oxide), flammable (propane), and corrosive (hydrogen chloride).

Remember

- Cylinders that are knocked over or dropped can be very dangerous. If a valve is knocked off, the cylinder can become a lethal projectile.
- Accidental releases may result in an oxygen-depleted atmosphere or adverse health effects.

The following guidelines will help ensure safe handling, use, and storage of compressed gas cylinders.

Receiving and Storage:

1. Cylinders should not be accepted unless the cylinder contents are clearly labeled.
2. Do not accept cylinders which are damaged or do not have a valve protection cap.
3. Carefully read the label before storing any compressed gas. The SDS will provide

additional hazard and storage information.

4. Compressed gas cylinders must be capped with valve protection cap, stored in a well ventilated location and secured in an upright position with straps or chains at all times. **Chains** are preferable, as they will not burn during a fire and will continue to secure the cylinder.
5. Multiple compatible cylinders may be secured together, only if they are capped (not in use).
6. Never place oxygen cylinders (oxidizing gases) near highly combustible materials, especially oil and grease, near stocks of carbide and acetylene or other fuel gas cylinders, nor near any other substance likely to cause or accelerate a fire.
    - Systems and components used for other gases and purposes must never be used for oxygen or interconnected with oxygen.
    - Signs should be clearly posted in areas where flammable compressed gases are stored, identifying the gases and the appropriate precautions to be taken.
7. Cylinders should have current hydrostatic test date (normally less than 5 years old for steel and 3 years old for aluminum) engraved on the cylinder. Cylinders should be returned to the supplier for servicing prior to the expiration date.
8. Do not place cylinders near heat, sparks, or flames or where they might become part of an electrical circuit.
9. Do not store cylinders in exit corridors or hallways.

Handling and Use

1. Before using a cylinder, read all label information and safety data sheets associated with the gas being used. Check the SDS for required personal protective equipment and hazard information before use.
2. Only use approved regulators, fittings and components which are permitted for the type of gas in the cylinder.
3. Do not use adapters to interchange regulators.
4. Be careful when threading a regulator onto a cylinder. They can become stuck, causing the gas to be released from the cylinder. This may result in oxygen depletion of the room, or in the development of a flammable atmosphere in the room.
5. Open cylinder valves slowly and face away from the valve when opening it. Ensure that others are not facing the valve when you open it.
6. Never force a gas cylinder valve. If the valve cannot be opened by the wheel or small wrench provided, the cylinder should be returned.
7. Transferring gases from one cylinder to another, refilling cylinders, or mixing gases in a cylinder in the laboratory is prohibited.
8. Use appropriate hand carts to move cylinders. Cylinders must be secured to the cart during transport with protective caps in place. Do not move gas cylinders by rolling them.
9. cylinders must be secured in an upright position with straps or chains and placed in well ventilated area in the lab.
10. All gas cylinders should be clearly marked indicating whether they are in use, full, or empty.
11. Use a leak check solution to detect leaks. Leak test the regulator, pigtail connections, and any piping system after performing maintenance or making modifications which could affect the integrity of the system. Always use a leak check solution that is approved for oxygen whenever leak checking oxygen or nitrous oxide cylinders.
12. Oil or grease on the high pressure side of an oxygen cylinder can cause an explosion. Do not lubricate an oxygen regulator.
13. Cylinders of toxic, corrosive or reactive gases should be purchased in the smallest quantity possible and stored/used in an approved ventilated gas cylinder storage cabinet, fume hood or under other approved local exhaust ventilation.

4.2 Health Hazards

A chemical is a health hazard if there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Each health hazard is defined and briefly discussed below.

4.2.1 Irritants

Irritants are defined as chemicals that cause reversible inflammatory effects on living tissue by chemical action at the site of contact. A wide variety of organic and inorganic compounds, including many chemicals that are in a powder or crystalline form, are irritants. Symptoms of exposure can include reddening or discomfort of the skin and irritation to respiratory systems.

4.2.2 Sensitizers

A sensitizer (allergen) is a substance that causes exposed individuals to develop an allergic reaction in normal tissue after repeated exposure to the substance. Examples of sensitizers include diazomethane, chromium, nickel, formaldehyde, isocyanates, arylhydrazines, benzylic and allylic halides, and many phenol derivatives. Sensitizer exposure can lead to all of the symptoms associated with allergic reactions, or can increase an individual's existing allergies.

4.2.3 Corrosives

Corrosive substances cause destruction of living tissue by chemical corrosion at the site of contact and can be either acidic or caustic (basic). Major classes of corrosive substances include:

- Strong acids such as sulfuric, nitric, hydrochloric and hydrofluoric acids
- Strong bases such as sodium hydroxide, potassium hydroxide, and ammonium hydroxide
- Dehydrating agents such sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide
- Oxidizing agents such as hydrogen peroxide, chlorine, and bromine

Precautions to take when working with corrosives:

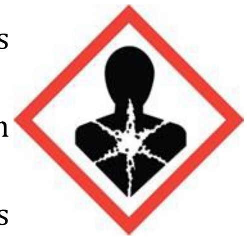
1. Eye protection and gloves should always be worn when handling corrosive materials. A face shield, rubber apron, and rubber boots may also be appropriate, depending upon the work performed (check the Safety Data Sheet for personal protective equipment requirements).
2. Always add acid to water. Dehydrating agents such as sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide should be mixed with water by adding the agent to water to avoid violent reaction and splattering.
3. An eyewash and safety shower must be immediately accessible in areas where corrosives are used and/or stored. In the event of skin or eye contact, immediately flush the area of contact with cool water for 15 minutes and remove all affected clothing. Get medical help immediately.
4. Strong oxidizing agents such as chromic and perchloric acids should be stored and used in glass or other inert containers (preferably unbreakable); corks and rubber stoppers should not be used
5. Safety rubber bottle carriers or non-breakable bottles (PVC-coated) should be used for the transport of strong acids and bases from one location to another.

Corrosive Materials Storage

The best storage method for corrosive materials is inside of a corrosive storage cabinet or lab cabinet where acids and bases are segregated at all times. Acids must also be segregated from chemicals where a toxic gas would be generated upon contact with an acid (e.g., cyanide or sulfide compounds). Organic acids (e.g., acetic acid, formic acid) must be stored away from oxidizing acids (e.g., nitric acid, perchloric acid), as these types of acids are incompatible with each other. Segregation can be achieved either by physical distance (preferred method) or by secondary containment.

4.2.4 Hazardous Substances with Toxic Effects on Specific Organs

Substances with toxic effects on specific organs include:



- **Hepatotoxins**, which are substances that produce liver damage, such as nitrosamines and carbon tetrachloride.
- **Nephrotoxins**, which are substances that cause damage to the kidneys, such as certain halogenated hydrocarbons.
- **Neurotoxins**, which are substances that produce toxic effects on the nervous system, such as mercury, acrylamide, and carbon disulfide.
- Substances that act on the **hematopoietic system** (e.g., carbon monoxide and cyanides), which decrease hemoglobin function and deprive the body tissues of oxygen.
- Substances that **damage lung tissue** such as asbestos and silica.

4.2.5 Particularly Hazardous Substances

Substances that pose such significant threats to human health are classified as "particularly hazardous substances" (PHSs). The OSHA Laboratory Standard requires that special provisions be established to prevent the harmful exposure of researchers to PHSs, including the establishment of designated areas for their use. Particularly hazardous substances are divided into three primary types:

1. Carcinogens
2. Reproductive Toxins
3. Substances with a High Acute Toxicity

4.2.5.1 Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally, they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. Chronic toxins are particularly insidious because they may have no immediately apparent harmful effects. These materials are separated into two classes:

1. **Select Carcinogens:** Select carcinogens are materials which have met certain criteria established by the National Toxicology Program or the International Agency for Research on Cancer regarding the risk of cancer via certain exposure routes. It is important to recognize that some substances involved in research laboratories are new compounds and have not been subjected to testing for carcinogenicity.
2. **Regulated Carcinogens:** Regulated carcinogens are more hazardous and have extensive additional requirements associated with them. The use of these agents may require personal exposure sampling based on usage. When working with Regulated Carcinogens, it is particularly important to review and effectively apply engineering and administrative safety controls as the regulatory requirements for laboratories that may exceed long term (8 hour) or short term (15 minutes) threshold values for these chemicals are very extensive.

4.2.5.2 Reproductive Toxins

Reproductive toxins include any chemical that may affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogens).

Reproductive toxins can affect the reproductive health of both men and women if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus; these effects include embryolethality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. For men, exposure can lead to sterility. Examples of embryotoxins include thalidomide and certain antibiotics such as tetracycline. Women of childbearing potential should note that embryotoxins have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin (e.g., formamide).

4.2.5.3 Substances with a High Acute Toxicity

Substances that have a high degree of acute toxicity are materials that may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration.

Acute toxins are quantified by a substance's lethal dose-50 (LD50) or lethal concentration-50 (LC50), which is the lethal dose of a compound to 50% of a laboratory tested animal population (e.g., rats, rabbits) over a specified time period. High acute toxicity includes any chemical that falls within any of the following OSHA-defined categories:

- A chemical with a median lethal dose (LD50) of 50 mg or less per kg of body weight when administered orally to certain test populations.
- A chemical with an LD50 of 200 mg less per kg of body weight when administered by continuous contact for 24 hours to certain test populations.
- A chemical with a median lethal concentration (LC50) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable manner.

Precautions

Precautions to take when working with carcinogens, reproductive, or highly toxic chemicals:

Know the hazards of the material you are using. Review the SDS and do additional research if necessary. Use less toxic materials when possible.

Use and store toxic chemicals in established areas and in the smallest possible amounts.

Store and transport toxic chemicals in secondary containment.

Use these materials in containment devices such as fume hoods and glove boxes.

2. Use appropriate protective equipment.
3. Be prepared for spills and know when to take emergency action.
4. Wash hands and arms immediately after working with toxic materials.
5. Never eat, drink, smoke, apply cosmetics, take medication, adjust contacts, or store food in areas where toxic substances are being used.
6. Dispose of wastes in accordance with Chemical Waste Management Procedures. As appropriate, perform chemical decontamination of washes and materials from experiments.
7. Consider whether additional precautions are needed for substances with high toxicity.
    - Areas to be designated for use and posted, e.g., fume hood, glove box, or entire room;
    - Containment devices (e.g., fume hood or glove box);
    - Procedures for decontamination and waste disposal; and
    - Additional training or personal protective equipment for material users.

Acutely Toxic Materials Storage

The following guidelines for storing acutely toxic materials must be followed in all laboratories:

1. Suitable storage locations for acutely toxic materials include desiccators, glove boxes, flammable storage cabinets that do not contain incompatible chemicals (primarily strong acids), or non-domestic refrigerators or freezers. These locations should be clearly labeled.
2. Acutely toxic materials should be stored in secondary containment at all times as a best management practice.
3. If possible, store all acutely toxic materials in a cabinet dedicated only for acutely toxic materials. Signs should be posted to indicate their presence and unique hazards.
4. The amount of acutely toxic material stored in the lab should be kept at a minimum. Any expired or unnecessary materials must be properly disposed of as hazardous waste.
5. All acutely toxic materials should be clearly labeled with the original manufacturer's label, which should have the chemical name, hazard labels, and pictograms. The label should not be defaced in any way.

4.2.6 Cryogenic Liquids

A cryogenic liquid is defined as a liquid with a normal boiling point below -150 °C (-238 °F). The most common cryogenic liquid used in a laboratory setting is liquid nitrogen. By definition, all cryogenic liquids are extremely cold. Cryogenic liquids and their vapors can rapidly freeze human tissue and can also pose an asphyxiation hazard if handled without proper ventilation. The following precautions should be taken when handling cryogenic liquids:

1. Read safety data sheet for the cryogenic liquid and check the hazard information before use.
2. Use and store cryogenic liquids in well ventilated areas only to avoid localized oxygen depletion (asphyxiation risk) or buildup of flammable or toxic gas.
3. Guard against skin damage by wearing appropriate PPE while handling cryogenic liquids. Proper PPE for handling cryogenic liquids includes chemical splash goggles, a face shield, cryogenic-safe gloves, long sleeves, as well as a garment and fully enclosed shoes covering all skin beneath the waist.
4. Cryogenic liquids will vent (boil off) from their storage containers as part of normal operation. Containers are typically of a vacuum jacketed design to minimize heat loss. Excessive venting and/or an isolated ice build-up on the vessel walls may indicate a fault in the vessel's integrity or a problem in the process line. A leaky container should be removed from service and taken to a safe, well-ventilated area immediately.
5. All systems components piping, valves, etc., must be designed to withstand extreme temperatures.
6. Pressure relief valves must be in place in systems and piping to prevent pressure build up. Any system section that could be valved off while containing cryogenic liquid must have a pressure relief valve. The pressure relief valve relief ports must be positioned to face toward a safe location.
7. Transfer operations involving open cryogenic containers, such as Dewars must be done slowly, while wearing all required PPE. Care must be taken not to contact non-insulated pipes and system components.
8. Transfers or pouring of cryogenic liquids should be done carefully to avoid splashing.
9. Do not use a funnel while transferring cryogenic liquids.
10. Use tongs or other similar devices to immerse and remove objects from cryogenic liquids; never immerse any part of your body into a cryogenic liquid.

4.2.7 Nanomaterials

Nanotechnology is the understanding, manipulation, and control of matter at dimensions of roughly 1 to 100 nanometers, which is near-atomic scale, to produce new materials, devices, and structures. One nanometer is one-billionth of a meter. Putting this size into perspective, a single human hair is about 80,000 nanometers in width and a red blood cell is about 7,000 nanometers in diameter.

Engineered nanoscale materials or nanomaterials are materials that have been purposefully manufactured, synthesized, or manipulated to have a size with at least one dimension in the range of approximately 1 to 100 nanometers and that exhibit unique properties determined by their size. In many cases, particles created at the nanoscale are found to have different chemical and physical properties than larger particles of the same material

Exposure to nanomaterials can occur through inhalation, absorption, injection, or ingestion. Toxicity will depend on the route of exposure and physical and chemical properties of the nanomaterial. Nanomaterials with known hazardous properties (e.g., carcinogens, mutagens, reproductive toxicants, sensitizers, reactive metals, etc.) as well as those that are photo-reactive, have highly-charged surfaces, are highly acidic/basic, soluble, fibrous (i.e., possess a high aspect ratio), and/or have other hazardous properties require further assessment and control measures.

Refer to the General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories for detailed procedures and guidance regarding the safe handling of nanomaterails.

5.0 Controlling Hazardous Chemicals

Laboratory Safety Considerations

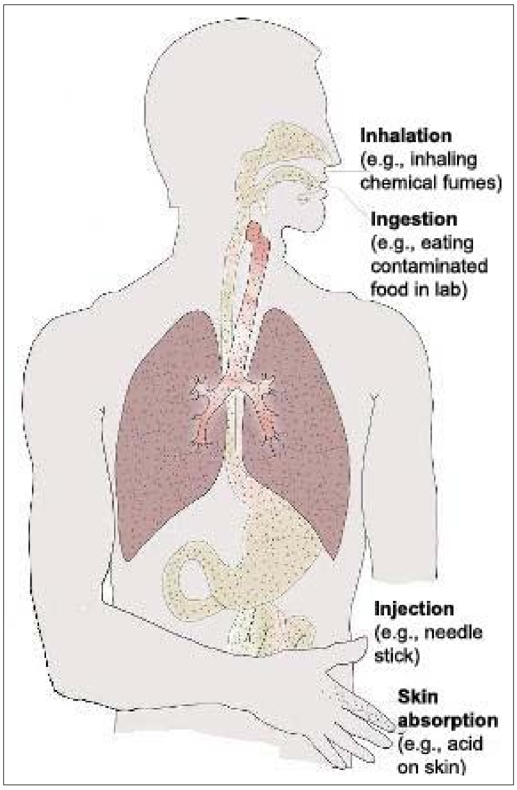
Many factors are involved in an effective laboratory safety plans. Considering the following questions will help address many of the factors that should be considered before work in the lab begins:

- Is the material flammable, explosive, corrosive, or reactive?
- Is the material toxic, and if so, how can I be exposed to the material (e.g., inhalation, skin or eye contact, accidental ingestion, accidental puncture)?
- What kind of ventilation do I need to protect myself?
- What kind of PPE (e.g., chemical-resistant gloves, respirator, and goggles) do I need to protect myself?
- Will the process generate other toxic compounds, or could it result in a fire, explosion, or other violent chemical reaction?
- What are the proper procedures for disposal of the chemicals?
- Do I have the proper training to handle the chemicals and carry out the process?
- Are my storage facilities appropriate for the type of materials I will be using?
- Can I properly segregate incompatible chemicals?
- What possible accidents can occur and what steps can I take to minimize the likelihood and impact of an accident? What is the worst incident that could result from my work?

5.1 Routes of Exposure

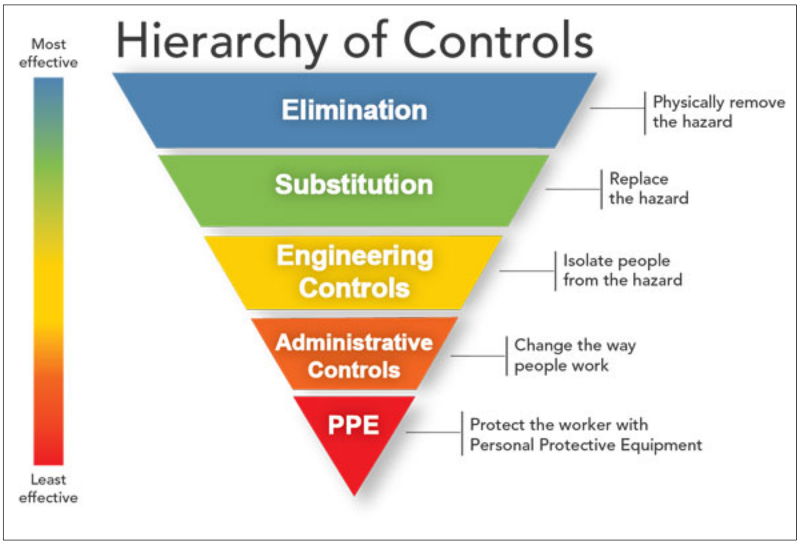
There are four primary routes of exposure in which hazardous substances can enter the body: inhalation, absorption (through skin or eyes), ingestion, and injection. Of these, the most likely routes of exposure in the laboratory are by inhalation or absorption so it is critical that protective measures must be in place for each of these exposure routes.

- **Inhalation**: Inhalation of gases, vapors, dusts, fumes or mists is a common route of exposure. Chemicals can enter and irritate the nose, airways and lungs. They can become deposited in the airways or be absorbed through the lungs into the bloodstream. The blood can then carry these substances to the rest of the body.
- **Absorption or Direct (skin/eye) contact**: Many chemicals can injure the skin directly (corrosives), while others may cause irritation or an allergic reaction. In addition to causing local effects, many chemicals may be absorbed through the skin and/or eyes in sufficient quantity to cause systemic effects. The main avenues by which chemicals enter the body through the skin are hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the skin. Direct contact effects and absorption of chemicals through the skin depend on a number of factors, including chemical concentration, chemical reactivity, solubility of the chemical in fat and water, condition of the skin, and duration of contact.
- **Ingestion**: Chemicals that get in or on food, cigarettes, utensils or hands can be swallowed. Substances can be absorbed into the blood and then transported to the rest of the body.
- **Injection**: Injections can occur through needles or broken contaminated glassware.



5.2 Hierarchy of Controls

Procedures must be followed in laboratories to both control the hazard and control worker exposure to the hazard. The hierarchy of controls prioritizes hazard mitigation strategies on the premise that the best way to control a hazard is to



5.2.1 Eliminate

the hazard from the workplace or

5.2.2 Substitute

with a less hazardous technique, process, or material.

If **elimination or substitution** are not feasible options; engineering controls, administrative controls, and PPE must be used to provide the necessary protection.

5.2.3 Engineering Controls

Engineering controls seek to control hazards at their source by designing the work environment or the job itself to eliminate or reduce exposure to hazards. A fundamental and very common example is the laboratory fume hood which is very effective at containing chemical hazards and protecting users from inhalation hazards. Other examples of engineering controls include general room ventilation, flammable material storage units, and secondary containment.

5.2.3.1 Fume Hoods

Fume hoods are the most important engineering control used in labs to protect workers from exposure to hazardous chemicals

To determine if a chemical is required to be used inside of a chemical fume hood, first check the SDS for that chemical. Statements found in Section 2 on a SDS such as "do not breathe dust, fumes, or vapors" or "toxic by inhalation" indicate the need for ventilation. As a best practice, always use a chemical fume hood for all work involving the handling of open chemicals (e.g., preparing solutions, transferring chemicals) whenever possible.

The following general rules should be followed when using laboratory hoods:

1. Wear appropriate personal protective equipment (PPE) at all times.
2. Place all materials in the fume hood at least 6 inches away from the edge of the fume hood face. When work is carried out within 6 inches of the edge, vapors, fumes, and particles are more likely to escape.
3. Work with the hood sash in the lowest practical position. The sash acts as a physical barrier in the event of an accident. Keep the sash closed when not conducting work in the hood.
4. Do not clutter your hood with unnecessary bottles or equipment that can block air circulation. Keep it clean and clear. Only materials actively in use should be in the hood.

5. Chemical fume hoods used for experimental work should not be used for chemical or equipment storage. Store chemicals in appropriate locations, such as a flammable storage cabinet, and bring them into the fume hood only when needed.
6. Never put your head inside of an operating chemical fume hood.
7. Keep the hood sash closed when not in use to safe energy.
8. Do not use the hood to volatilize chemicals or wastes
9. Never use electrical outlets inside the hood. Run all equipment cords to outlets outside of the hood.
10. Elevate large equipment (e.g., a centrifuge) at least two inches off the base of the hood interior.
11. Fume hoods must remain working at all times when chemicals are present in the hood.
12. Chemical fume hoods should be inspected upon installation, renovation, when a deficiency is reported, or a change has been made to the operating characteristics of the hood.
13. Never work in a fume hood that is not running properly. Remove chemicals from hood, close the sash, and contact CL Engineers

5.2.3.2 Other Sources of Ventilation

In addition to fume hoods other forms of ventilation including gloveboxes, biosafety cabinets, canopy hoods, clean benches, ductless fume hoods, etc. may be present in labs.

Glove boxes:
Glove boxes may be used for working with reactive chemicals under an inert environment or for working with very toxic substances in a completely closed system. These units can be very effective because they offer complete containment.

Biosafety cabinet:
A biological (or biosafety) safety cabinet is an enclosed, ventilated laboratory workspace used for safely working with materials contaminated with (or potentially contaminated with) infectious materials. The primary purpose of a biosafety cabinet is to serve as a means to protect the laboratory worker and the surrounding environment from pathogens. All exhaust air is filtered as it exits the biosafety cabinet, removing harmful particles.

Biological safety cabinets are not designed to be used with chemical applications so never use hazardous chemicals in these cabinets. Applications that involve the use of chemicals should be conducted in chemical fume hoods.

5.2.3.3 Refrigerators and Freezers

Flammable-safe refrigerators and Freezers are designed to eliminate ignition of flammable vapors inside the storage compartment (by locating the compressor and other circuits that can arc/create a spark on the exterior of the unit).

The following procedures must be followed when storing chemicals in refrigerators or freezers in the laboratory:

1. Never use a domestic refrigerator to store flammables because they contain ignition sources that can set off explosive concentrations of flammable vapor. Vapors from a leaky stopper or a cracked container can build up to explosive concentrations and be ignited by the light switch or thermostat.
2. Domestic refrigerators/freezers located in labs must be labeled "Do Not Store Flammables in This Refrigerator/freezer."
3. Flammable chemicals must be stored in an approved explosion-proof or flammable storage refrigerator or freezer.

4. Ensure that the chemicals stored in a refrigerator or freezer is compatible with each other. For example, do not store an oxidizer such as hydrogen peroxide in a refrigerator with organic chemicals. Limited quantities of incompatible hazard classes that require refrigeration must be segregated in separate secondary containment bins with tight-fitting caps or lids.
5. Never store uncapped or partially opened containers (e.g., chemicals covered with aluminum foil, glass stoppers, wooden corks, etc.) of chemicals in a refrigerator/freezer.
6. Samples and chemicals stored in refrigerators must be appropriately labeled.
7. Shelves in refrigerators or freezers should all have suitable plastic trays for secondary containment in the refrigerator and freezer compartments. If plastic trays are not available, liquid chemicals should be placed in secondary containers to contain spills.
8. An inventory should be posted on the refrigerator door.
9. Chemical refrigerator or freezers should be located away from laboratory exits.
10. Refrigerators and freezers should be cleaned-out and manually defrosted as necessary.
11. When defrosting a freezer, safety precautions should be taken regarding potential chemical contamination of the water.
12. Remember that power outages and technology failures can cause internal temperatures to rise, which can impact chemical contents. Be aware of unusual odors, vapors, etc., when opening the refrigerator or freezer.

Cold rooms in W12 and M32 are not designed for storage of flammable or volatile materials. They may have exposed ignition sources and are not ventilated to actively remove chemical contaminants. Therefore, undesirable vapors may become concentrated if these types of materials are stored in cold rooms.

5.2.3.4 Chemical Storage Cabinets

Chemical storage cabinets are designed to store flammable liquids, corrosives, and other hazardous materials to help protect lab personnel and facility from a potential fire or spillage. These cabinets are typically made from materials that are resistant to the chemicals stored in them and occasionally contain a tray to capture spillage. Chemical storage cabinets are usually suited for specific classes of chemicals. Acid cabinets, for example, consist of corrosion-resistant materials and sealing to prevent the leakage of fumes. Flammable solvent cabinets are produced from a metal able to resist fire for at least 10-30 minutes. The cabinet features include:

- Keep dangerous liquids safely organized and segregated
- Ensure safe evacuation time in the event of a fire
- Provide compliance with local and international regulations.
- Manage quantities of flammable and combustible liquids in control areas.
- Improve efficiency by locating materials near point-of-use.
- Improve security with locking mechanism.

5.2.4 Administrative Controls

Administrative controls are policies, work practices, and procedures designed to limit or prevent personnel exposure to workplace hazards. Administrative controls are often used in conjunction with engineering controls and personal protective equipment. Examples of administrative controls include:

5.2.4.1 Information and Training

All lab employees who works with, or is exposed to potentially hazardous chemicals in a laboratory must read and understand the chemical hygiene plan to know the hazards of those chemicals and the control measures that should be taken to avoid the exposure.

Central Labs Directorate is providing general lab safety training though an online training system. However, training specific on hazards of chemicals, equipment, or operations for the particular lab where an employee is assigned is the responsibility of that employee's supervisor and his/her department, and must be provided before initial assignment. Documentation of the training, including the content, training date, and signatures, is recommended. See Appendix 2

The intent of training is to assure that all employees are informed about hazards and protection when working in the lab.

Laboratory employees should be familiar of the location and content of the following:

- Chemical Hygiene Plan
- Safety Data Sheets (SDSs)
- Central labs safety manual
- Emergency Response Guide

5.2.4.2 General Laboratory Safety Rules

The following general laboratory safety rules should be followed by lab personnel at all times:

1. **Working alone**. Avoid working alone in the laboratory. If you must work alone or in the evening, let someone else know and have them periodically check on you. However, **never** work with high hazard chemicals or perform high hazard operations alone. Notify others in the lab that you will be working with highly hazardous chemicals and plan your work so that this is done during normal working hours.
2. **Housekeeping**:
   2.1 Proper housekeeping includes appropriate labeling and storage of chemicals, safe and regular cleaning of the facility, and proper arrangement of laboratory equipment.
   2.2 Exits, aisles and Emergency equipment must not be obstructed in any way with equipment, furniture, supplies, etc.
   2.3 All work areas and floors should be kept free of clutter and not to be used for excessive storage.
3. **Equipment, tools, and glassware**. Use proper equipment that is in good condition. never use chipped or cracked glassware. Shield pressurized or vacuum apparatus and safeguard against bumping or overheating.
4. **Chemical wastes**. Properly dispose of chemical wastes as per the procedures outlined in this document.
5. **Lab Emergencies**. Prior to beginning work in the lab, be prepared for hazardous materials emergencies and know what actions to take in the event of an emergency. Plan for the worst-case scenario. Be sure that necessary supplies and equipment are available for handling small spills of hazardous chemicals. Know the location of safety equipment such as the nearest safety shower and eyewash station, fire extinguisher, spill kit, and fire alarm call points.
6. **Chemical Information.** Always read and understand the SDS, and the label before using a chemical in the laboratory and make others in the laboratory aware of any special hazards associated with your work.
7. **Personal Hygiene**. Wash hands with soap and water immediately after working with any laboratory chemicals, even if gloves have been worn. Remove contaminated clothing and gloves before leaving laboratory. Never touch your cell phone, door handles, elevator buttons, etc. with gloved hands.
8. **Mouth pipetting**. Mouth pipetting is forbidden only use mechanical devices, such as pipet bulbs, pipet wheels, electric pipettes, etc.
9. **Food, drink and cosmetics**. Eating, drinking, and the application of cosmetics are forbidden in areas where hazardous chemicals are used. Do not store food or drink in the same refrigerator with chemicals.
10. **Never** smell or taste a hazardous chemical.
11. **Wear appropriate PPE** when handling hazardous materials.
12. **Signs and Posters**. Using safety signs or posters to identify hazardous areas (designated areas).

13. **Appropriate ventilation** Always use adequate ventilation with chemicals. Operations using volatile or toxic substances should only be performed in a chemical fume hood.
14. **Unattended operations**. If you are doing laboratory work involving hazardous substances that occur continuously or overnight, when no one is present in the laboratory, you need to post a sign on the fume hood or at the door to the lab, indicating your name, contact information, and hazardous materials involved. It is the responsibility of the researcher/lab supervisor to design the overnight reactions with control measures to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas.
15. **Risk assessments**. Carry out risk assessments when planning out experiments, before beginning new processes or operations. See Appendix 3
16. **Safety Training.** Complete required safety training prior to beginning work. Training is required before beginning work with chemicals in a University laboratory.
17. **Malfunctioning** laboratory equipment (such as a chemical fume hood) should be identified as "out of service" so that others will not inadvertently use it before repairs are made. Contact CLD Maintenance Section to repair fume hood as soon as possible.
18. **Laboratory Security:** For liability, safety, and security reasons, do not allow unauthorized persons in the laboratory and restricting access to areas where hazardous materials are used. Laboratories shall be closed when no one is present.
19. **Prior Approvals.** Obtain prior approval to proceed with a laboratory procedure from the lab supervisor/ lab faculty member when:
    - Working with highly hazardous substances (highly toxic gases, extremely reactive chemicals, etc.)
    - Performing particularly hazardous procedures (i.e., potential for violent reaction); and/or
    - Working alone with particularly hazardous materials or hazardous procedures
    - Leaving operations unattended
20. **Never** perform unauthorized experiments.
21. **Horseplay**. Horseplay is prohibited.
22. **Particularly dangerous chemicals.** Use only those chemicals for which you have the appropriate exposure controls, for example, Perchloric acid. If Perchloric acid is heated above ambient temperature it will give off vapors that can condense and form explosive perchlorates. Hence, when heating Perchloric acid above ambient temperature, a Perchloric acid hood with a wash down system or a local scrubbing or trapping system should be used.
23. **Mercaptans**. To avoid false reporting of natural gas leaks, logs of mercaptan use should be kept when Mercaptans will be used in a laboratory and you should inform Central Labs Directorate to notify the lab staff for the smell as the persons outside the laboratory could smell the mercaptan and suspect a natural gas leak in the building.
24. **Incident Reporting**. Report all injuries, accidents, incidents, and near misses to CLD.

5.2.4.3 Standard Operating Procedures (SOPs)

SOPs are written instructions that clearly outlines the steps to be followed when carrying out a given operation or experiment so that a process can be performed in a safe manner by any person reading it. These SOPs should address hazards of the activity or material(s) as well as the safety measures necessary to protect personnel and students from the exposure to hazardous materials in the laboratory.

This general chemical hygiene plan, along with safety data sheets (SDS), may be sufficient as the primary source of information for pre-planning certain simple lab activities or experiments. However, laboratory personnel/researchers who are the most knowledgeable and involved with the experimental process are required to develop more detailed procedures as their situations warrant. Priority for SOP development should be given to any operation involving restricted and higher hazard chemicals, such as Particularly Hazardous Substances and Highly Reactive Chemicals, and specified higher-risk research procedures. The SOP needs to be approved by the lab/research supervisor.

The SOP needs to contain the following information at a minimum:

1. Process or Experiment Description
2. Risk Assessment
   - 2.1. Identify Hazards
   - 2.2. Potential risks
   - 2.3. Control of Hazards
     - 2.3.1. Engineering/Ventilation Controls
     - 2.3.2. Administrative controls
       - 2.3.2.1. Special Handling Procedures and Storage Requirements
       - 2.3.2.2. Training Requirements
       - 2.3.2.3. Prior Approval
     - 2.3.3. Personal Protective Equipment
3. Step-By-Step Operating Procedure
4. Waste Disposal
5. Emergency Procedures
   - 5.1. Emergency Equipment
   - 5.2. Spill and Accident Procedures
   - 5.3. Decontamination Procedures
   - 5.4. First Aid Procedures
6. Document training on the SOP

Labs may use a standard SOP template provided in Appendix 4

5.2.5 Personal Protective Equipment

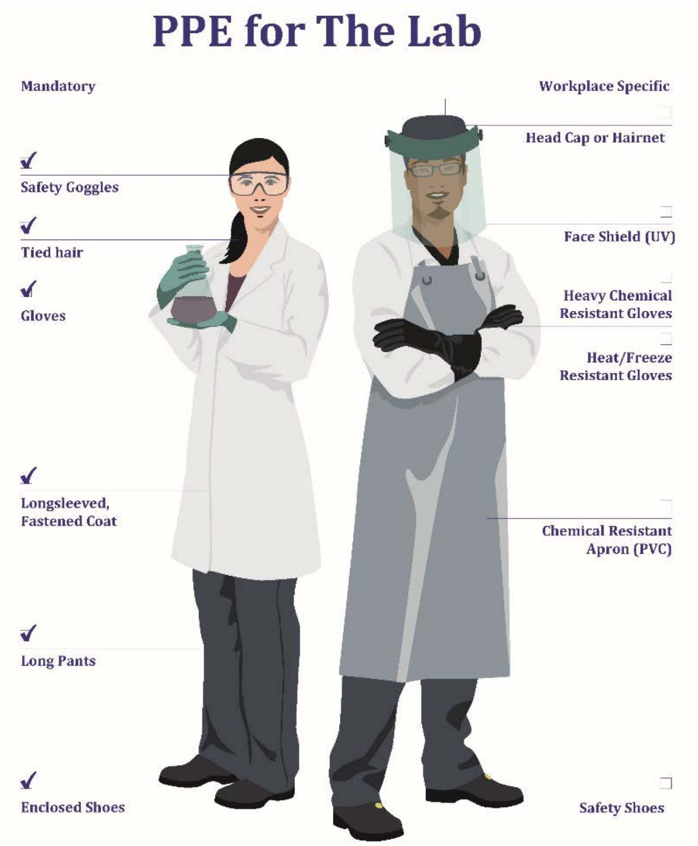
Appropriate PPE is essential for personal protection and is used in combination with engineering and administrative controls. PPE alone does not provide adequate control of hazardous chemicals but is an effective method to reduce exposure in the event that engineering and administrative controls cannot adequately minimize the risk as it is creating a barrier against workplace hazards. PPE should never be used as a substitute for engineering controls when engineering controls are required. The minimum PPE that must be worn at all time in labs where hazardous chemicals are handled are goggles or safety glasses, clothing that covers the legs, and closed-toed footwear. Proper PPE selection can be determined from the following resources:

- Review Section 8, "Exposure Controls/Personal Protection" of the SDS for the chemical(s) being used. This will provide basic information on the PPE recommended for use with the particular chemical.
- Review the SOP and associated risk assessment for the task to be performed.

It is the responsibility of the lab supervisors/researchers to determine what PPE is necessary for the specific task they are performing. See Appendix 8 for PPE Selection Guide.

In general, Personal Protective Equipment (PPE) includes:

- **Protective Clothing** that covers a majority of the skin to protect from spills (e.g., laboratory coats)
- **Eye/Face Protection** should be worn when working with chemicals (e.g., safety glasses, goggles, face shield) splash goggles should be considered, especially when working with concentrated acids or any harmful chemical.
- **Hand Protection** to match the hazard (e.g., chemical-resistant gloves, thermal protection gloves, cut-resistant gloves) you may use the [Ansel Online Chemical Hand Protection Guide] to find the proper gloves
- **Protective Footwear** (e.g., safety shoes, closed shoes) (sandals, flip-flops, clogs, or other footwear that expose the front, top, side or back of the feet are not allowed).
- **Hearing Protection** (e.g., earplugs, ear muffs)
- **Respiratory Protection** (e.g., N95 filtering face-piece, half-face respirator).



6.0 Emergency Procedures

Laboratory emergencies may result from a variety of factors, including serious injuries, fires and explosions, spills and exposures, and natural disasters and can cause serious consequences as personal injury, property damage, environmental impact, and disruption of academic research, so it is best to be prepared before it happens. Spend time before each semester to become familiar with the location and use of Emergency Response Guide/Poster, safety manuals, Safety Data sheets, and Emergency Equipment such as first aid kits, safety showers, eyewash stations, fire extinguishers, circuit breakers, fire alarm call points, and spill kits. **All lab emergencies must be reported to Central Labs Directorate** through an Incident Report which can be found online on Central Labs Safety Portal. The report should be completed within 24 hours of the incident. In emergency situations you must contact the UOS Emergency Numbers for help, see Appendix 11.

General procedures to be followed in any emergency are found in the CLD Emergency Response Guide.

6.1 Medical Examination and Consultation

Laboratory personnel shall seek medical attention under the following conditions:

- An individual develops signs or symptoms associated with exposure to hazardous chemicals in the laboratory.
- An accident such as a spill, leak, equipment failure, or explosion results in possible over-exposure to hazardous chemicals.
- Any work-related injury

Information Provided to Physician

The following information must be provided to the examining physician.

- The SDS for the applicable hazardous chemical(s)
- The conditions and type of exposure.
- The signs and symptoms of exposure that the person is experiencing, if any

Upon completion of the examination, the physician will provide the medical reports includes the following:

- Examination and test results.
- Recommendations for further follow up examination.
- Any medical condition of the employee which places them at risk as a result of exposure to hazardous chemicals found in their workplace

* The medical reports must be submitted to CLD.

6.2 Don't Learn Safety by Accident

Lab personnel are encouraged to browse the below incidents or use the google search to locate related reports. Use Lessons learned to improve safety in your lab.

Texas A&M-Qatar cancels classes after staffer killed in laboratory accident

Refrigerator Explosion at Michigan State University

Texas Tech University Chemistry Lab Explosion

Gas Cylinder Explosion Kills Researcher at Indian Laboratory

The University of California, Los Angeles lab fire fatality

Yale Student Killed in lab accident as Hair Gets Caught in Lathe A

Dartmouth researcher died from exposure to dimethyl mercury

Graduate student gets prison sentence for poisoning

For more lab accidents click here

7.0 References and Additional Resources

Additional information on safety in chemical laboratories can be found in the following publications.

- **Identifying and Evaluating Hazards in Research Laboratories**. These are the 2015 guidelines developed by the hazards identification and evaluation task force of the American Chemical society's (ACS's) committee on chemical safety.
- **Prudent Practices for Handling Hazardous Chemicals in the Laboratory** issued by National Research Council and published by National Academy Press.
- **Safety in the use of chemicals at work** by the International Labour Office in Geneva.
- The **National Institute for Occupational Safety and Health (NIOSH) guide** to Chemical Hazards published by the CDC.
- ACS publications **Safety in Academic Chemistry Laboratories Vol 1***Accident prevention for college and university students* and **Accident prevention for faculty and administrators**.
- **OSHA Laboratory Safety Guidance**
- **Hazard Assessment in Research Laboratories**
- **Promoting a Culture of Safety in Academic Chemical Research (2014)**
- **Chemical Laboratory Safety and Security:** A Guide to Developing Standard Operating Procedures (2016)
- A Guide to The Globally Harmonized System of Classification and Labeling of Chemicals (GHS)
- **OSHA Hazard Classification Guidance**

8.0 Appendices

8.1 Appendix 1: Definitions

Absorbed Dose. The amount of a substance that actually enters into the body, usually expressed as milligrams of substance per kilogram of body weight (mg/kg).

ACGIH. The American Conference of Governmental Industrial Hygienists is an organization of government and academic professionals engaged in occupational safety and health programs. ACGIH establishes recommended occupational exposure limits for chemical substances and physical agents known as Threshold Limit Values; see TLV.

Acute. Short duration, rapidly changing conditions.

Acute Exposure. An intense exposure over a relatively short period of time.

Acute Dose. The amount of a substance administered or received over a very short period of time (minutes or hours), usually within 24 hours.

Acute Toxicity. Those adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.

Alkali. (Also referred to as a base). A compound that has the ability to neutralize an acid and form a salt. Alkali also forms a soluble soap with a fatty acid. Alkalis have pH values between 7 and 14. They are bitter in a water solution. Alkalis with pH values between 12 and 14 are considered to be corrosive (caustic) and will cause severe damage to the skin, eyes and mucous membranes. Common strong alkalis are the substance sodium and mixture potassium hydroxide.

Allergic Reaction. An abnormal immunologic response in a person who has become hypersensitive to a specific substance. Some forms of dermatitis and asthma may be caused by allergic reactions to chemicals.

ANSI. The American National Standards Institute is a privately funded, voluntary membership organization that identifies industrial and public needs for national consensus standards and coordinates development of such standards.

Asphyxiant - A chemical (gas or vapor) that displaces oxygen in the ambient atmosphere, and can thus cause oxygen deprivation in those who are exposed, leading to unconsciousness and death. Simple asphyxiants, such as nitrogen, either remove or displace oxygen in the air. They become especially dangerous in confined or enclosed spaces. Chemical asphyxiants, such as carbon monoxide and hydrogen sulfide, interfere with the body's ability to absorb or transport oxygen to the tissues.

Aspiration. The entry of a liquid or solid chemical directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system.

ASTM. The American Society for Testing and Materials develops voluntary consensus standards for materials, products, systems, and services. ASTM is a resource for sampling and testing methods, information on health and safety aspects of materials, safe performance guidelines, and effects of physical agents, biological agents, and chemicals.

Autoignition Temperature. The lowest temperature at which a flammable gas or vapor-air mixture will spontaneously ignite without spark or flame. Vapors and gases will spontaneously ignite at lower temperatures as the concentration of oxygen increases in the air. The autoignition temperature may also be influenced by the presence of catalytic substances. Materials should not be heated to greater than 80% of the autoignition temperature.

Boiling Point (BP). The temperature at which a liquid changes to a vapor state, at a given pressure; usually expressed in degrees of Fahrenheit or Centigrade at sea level pressure (760 mm Hg or one atmosphere). Flammable materials with low boiling points generally present special fire hazards.

- **Initial boiling point** is the temperature of a liquid at which its vapor pressure is equal to the standard pressure (101.3 kPa; 14.7 psi), i.e., the first gas bubble appears.

CAS Number. A number assigned to a specific chemical by the Chemical Abstracts Service, an organization operated by the American Chemical Society. CAS Numbers are used internationally to identify specific chemicals or mixtures.

Carcinogen. A substance or a mixture of substances which induce cancer or increase its incidence. Substances and mixtures which have induced benign and malignant tumors in well-performed experimental studies on animals are considered also to be presumed or suspected human carcinogens unless there is strong evidence that the mechanism of tumor formation is not relevant for humans.

Chemical Hygiene Plan (CHP). Is a written program stating the policies, procedures and responsibilities that protect workers from the health hazards associated with the hazardous chemicals used in that particular workplace.

Chronic Toxicity. Adverse effects resulting from repeated doses or exposures to a substance over a relatively prolonged period of time.

Controlled Substances. Drugs and certain other chemicals, both narcotic and non-narcotic, which come under the jurisdiction of federal Drug Enforcement Administration (DEA) and state laws regulating their manufacture, sale, distribution, use, and disposal.

Combustible Liquid. Any liquid having a flash point at or above 100ºF (37.8ºC) but below 200ºF (93.3ºC), except for mixtures having components with flash points of 200ºF (93.3ºC) or higher, the total volume of which makes up 99% or more of the total of the mixture.

Decomposition. Breakdown of a material or substance into simpler substances by heat, chemical reaction, electrolysis, decay, or other processes.

DNA. Deoxyribonucleic acid; the molecules in the nucleus of the cell that contain genetic information.

Dose. The amount of a substance received at one time. Dose is usually expressed as administered or absorbed dose (e.g., milligrams material/kilogram of body weight).

DOT. U.S. Department of Transportation; the federal agency that regulates transportation of chemicals and other hazardous and non-hazardous substances.

EPA - The Environmental Protection Agency - the governmental agency responsible for administration of laws to control and/or reduce pollution of air, water, and land systems.

Epidemiology. The branch of science concerned with the study of human disease in specific populations, in order to develop information about the causes of disease and identify preventive measures.

Explosive Limits. The range of concentrations of a flammable gas or vapor (percent by volume in air) in which an explosion can occur if an ignition source is present. Also see Flammable Limits, LEL, and UEL.

Explosive chemical. A solid or liquid chemical which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic chemicals are included even when they do not evolve gases.

- **Pyrotechnic chemical.** A chemical designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative self-sustaining exothermic chemical reactions.
- **Explosive item**. An item containing one or more explosive chemicals.
- **Pyrotechnic item**. An item containing one or more pyrotechnic chemicals.
- **Unstable explosive**. An explosive which is thermally unstable and/or too sensitive for normal
- **Intentional explosive**. A chemical or item which is manufactured with a view to produce a practical explosive or pyrotechnic effect.

Flammable. A material which is easily ignited and burns with extreme rapidity. The two primary measures of this physical hazard are the flashpoint and the autoignition temperature.

Flammable gas. A gas having a flammable range with air at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi).

Flammable liquid. A liquid having a flashpoint of not more than 93°C (199.4°F).

Flammable solid. A solid which is a readily combustible solid, or which may cause or contribute to fire through friction.

- **Readily combustible solids**. Powdered, granular, or pasty chemicals which are dangerous if they can be easily ignited by brief contact with an ignition source, such as a burning match, and if the flame spreads rapidly.

Flashback. Occurs when flame from a torch burns back into the tip, the torch, or the hose. It is often accompanied by a hissing or squealing sound with a smoky or sharp-pointed flame.

Flashpoint. The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.

Genotoxic and genotoxicity. These apply to agents or processes which alter the structure, information content, or segregation of DNA, including those which cause DNA damage by interfering with normal replication processes, or which in a non-physiological manner (temporarily) alter its replication. Positive genotoxicity test results are usually taken as indicators for mutagenic effects.

Hazard category. The division of criteria within each hazard class, e.g., oral acute toxicity and flammable liquids include four hazard categories. These categories compare hazard severity within a hazard class and should not be taken as a comparison of hazard categories more generally.

Hazard class. The nature of the physical or health hazards, e.g., flammable solid, carcinogen, acute toxicity.

Hazardous chemical. Any chemical which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified.

IARC. International Agency for Research on Cancer, a component of the World Health Organization, located in Lyon, France.

Ignitable. A solid, liquid or compressed gas which is capable of being set afire.

Inhalation. Breathing in of a substance in the form of a gas, vapor, fume, mist, or dust.

Inhibitor - A substance that is added to another to prevent or slow down an unwanted reaction or change.

In Vitro. Outside a living organism (e.g., in a test tube).

Latency Period. The time that elapses between exposure and the first manifestations of disease or illness.

LC50 - Lethal Concentration 50, 50% Lethal Concentration. The concentration of a chemical in air or of a chemical in water which causes the death of 50% (one half) of a group of test animals. The LC50 can be expressed in several ways:

- as parts of material per million parts of air by volume (ppm) for gases and vapors,
- as micrograms of material per liter of air (mg/l), or
- as milligrams of material per cubic meter of air (mg/m3) for dusts and mists, as well as for gases and vapors.

LD50 - Lethal Dose 50. The amount of a chemical, given all at once, which causes the death of 50% (one half) of a group of test animals. The LD50 dose is usually expressed as milligrams or grams of material per kilogram of animal body weight (mg/kg or g/kg).

LEL or LFL - Lower Explosive Limit or Lower Flammable Limit. Lowest concentration of a substance in air (usually expressed in percent by volume) that will produce a flash or fire when an ignition source (heat, electric arc, or flame) is present. At concentrations lower than the LEL, propagation of a flame will not occur in the presence of an ignition source. Also see UEL.

mg/kg. Milligrams of substance per kilogram of body weight, commonly used as an expression of toxicological dose (e.g., 15 mg/kg).

mg/m3. Milligrams per cubic meter; a unit for measuring concentrations of particulates or gases in the air (a weight per unit volume). For example, 20 mg/m3.

Mutation. A permanent change in the amount or structure of the genetic material in a cell. The term "*mutation*" applies both to heritable genetic changes that may be manifested at the phenotypic level and to the underlying DNA modifications when known (including, for example, specific base pair changes and chromosomal translocations). The terms "*mutagenic*" and "*mutagen"* are used for agents giving rise to an increased occurrence of mutations in populations of cells and/or organisms.

NFPA. The National Fire Protection Association is an international membership organization which promotes fire protection and prevention and establishes safeguards against loss of life and property by fire.

NIOSH. The National Institute for Occupational Safety and Health is a part of the Centers for Disease Control and Prevention, U.S. Public Health Service, U.S. Department of Health and Human Services.

Odor Threshold. The lowest concentration of a substance in air that can be detected by smell.

PEL - Permissible Exposure Limit. A legally enforceable occupational exposure limit established by OSHA, usually measured as an eight-hour time-weighted average, but also may be expressed as a ceiling concentration exposure limit.

Personal Protective Equipment (PPE)- Any devices or clothing worn by the worker to protect against hazards in the environment. Examples are respirators, gloves, safety glasses.

Precursor Chemical. Chemicals used in the course of legitimate research that can potentially be used in the illicit production of Controlled Substances such as methamphetamine, cocaine, heroin, and MDMA (ecstasy).

ppm. Parts per million; the proportion (by volume) of a gas or vapor per million parts of air; also the concentration of a chemical in a liquid or solid form.

Reproductive toxicity. This hazard includes *adverse effects on sexual function and fertility* in adult males and females, as well as *adverse effects on development of the offspring*. Some reproductive toxic effects cannot be clearly assigned to either impairment of sexual function and fertility or to developmental toxicity. Nonetheless, chemicals with these effects shall be classified as reproductive toxicants.

- ***Adverse effects on sexual function and fertility.*** Any effect of chemicals that interferes with reproductive ability or sexual capacity. This includes, but is not limited to, alterations to the female and male reproductive system, adverse effects on onset of puberty, gamete production and transport, reproductive cycle normality, sexual behavior, fertility, parturition, pregnancy outcomes, premature reproductive senescence, or modifications in other functions that are dependent on the integrity of the reproductive systems.

Adverse effects on development of the offspring. Any effect of chemicals which interferes with normal development of the conceptus either before or after birth, which is induced during pregnancy or results from parental exposure. These effects can be manifested at any point in the life span of the organism. The major manifestations of developmental toxicity include death of the developing organism, structural abnormality, altered growth and functional deficiency.

Respiratory sensitizer. A chemical that will lead to hypersensitivity of the airways following inhalation of the chemical.

Self-accelerating decomposition temperature (SADT). The lowest temperature at which self-accelerating decomposition may occur with a substance as packaged.

Self-heating chemical. A solid or liquid chemical, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is liable to self-heat; this chemical differs from a pyrophoric liquid or solid in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days).

- Self-heating of a substance or mixture is a process where the gradual reaction of that substance or mixture with oxygen (in air) generates heat. If the rate of heat production exceeds the rate of heat loss, then the temperature of the substance or mixture will rise which, after an induction time, may lead to self-ignition and combustion.

Self-reactive chemicals. Thermally unstable liquid or solid chemicals liable to undergo a strongly exothermic decomposition even without participation of oxygen (air).

Serious eye damage. The production of tissue damage in the eye, or serious physical decay of vision, following application of a test substance to the anterior surface of the eye, which is not fully reversible within 21 days of application.

Skin corrosion. The production of irreversible damage to the skin; namely, visible necrosis through the epidermis and into the dermis, following the application of a test substance for up to 4 hours. Corrosive reactions are typified by ulcers, bleeding, bloody scabs, and, by the end of observation at 14 days, by discoloration due to blanching of the skin, complete areas of alopecia (baldness), and scars. Histopathology should be considered to evaluate questionable lesions.

Skin irritation. The production of reversible damage to the skin following the application of a test substance for up to 4 hours.

Skin sensitizer. A chemical that will lead to an allergic response following skin contact.

Specific target organ toxicity - single exposure (STOT-SE). Specific, non-lethal target organ toxicity arising from a single exposure to a chemical. All significant health effects that can impair function, both reversible and irreversible, immediate and/or delayed.

Specific target organ toxicity - repeated exposure (STOT-RE)*.* Specific target organ toxicity arising from repeated exposure to a substance or mixture. All significant health effects that can impair function, both reversible and irreversible, immediate and/or delayed.

STEL. Short-Term Exposure Limit (ACGIH terminology); see TLV.

Target Organ. An organ on which a substance exerts a toxic effect.

Teratogen. A substance that can cause malformations or alterations in the appearance or function of a developing embryo.

TLV - Threshold Limit Value. The occupational exposure limit published by the American Conference of Governmental Industrial Hygienists (ACGIH). ACGIH expresses Threshold Limit Values in four ways:

- **TLV-TWA: The allowable Time-Weighted Average -** A concentration for a normal 8-hour workday or 40-hour workweek.
- **TLV-STEL: Short-Term Exposure Limit -** A maximum concentration for a continuous 15-minute exposure period (maximum of four such periods per day, with at least 60 minutes between exposure periods, and provided the daily TLV-TWA is not exceeded).
- **TLV-C - Ceiling limit -** A concentration that should not be exceeded even instantaneously.
- **TLV-Skin -** The skin designation refers to the potential contribution to the overall exposure by the cutaneous route, including mucous membranes and the eye. Exposure can be either by airborne or direct contact with the substance. This designation indicates that appropriate measures should be taken to prevent skin absorption.

Toxic Substance. Any substance that can cause injury or illness, or which is suspected of being able to cause injury or illness under some conditions.

Toxicity. A relative property of a chemical agent that refers to a harmful effect on some biological mechanism and the conditions under which this effect occurs.

Toxicology. The study of the harmful interactions of chemicals on living organisms and biological systems.

TWA. Time-Weighted Average; the concentration of a material to which a person is exposed, averaged over the total exposure time – generally the total workday (8 to 12 hours); also see TLV.

UEL or UFL. Upper explosive limit or upper flammable limit; the highest concentration of a vapor or gas (highest percentage of the substance in air) that will produce a flash of fire when an ignition source (e.g., heat, arc, or flame) is present. At higher concentrations, the mixture is too "rich" to burn. Also see LEL.

Unstable. Decomposing readily or another unwanted chemical change during normal handling or storage.

Vapor density. The weight of a vapor or gas compared to the weight of an equal volume of air is an expression of the density of the vapor or gas. Materials lighter than air (e.g., acetylene, methane, hydrogen) have vapor densities less than 1.0. Materials heavier than air (e.g., propane, hydrogen sulfide, and ethane) have vapor densities greater than 1.0. All vapors and gases will mix with air, but the lighter materials will tend to rise and dissipate (unless confined). Heavier vapors and gases are likely to concentrate in low places along or under floors, in sumps, sewers, manholes, trenches, and ditches, where they may create fire or health hazards.

Vapor pressure. Pressure exerted by a saturated vapor above its liquid in a closed container. Three facts are important to remember:

- Vapor pressure of a substance at 100° F will always be higher than the vapor pressure of the substance at 68° F (20° C),
- Vapor pressures reported on SDSs in millimeters of mercury (mmHg) are usually very low pressures; 760 mmHg is equivalent to 14.7 pounds per square inch (psi).
- The lower the boiling point of a substance, the higher its vapor pressure.

Volatility. The tendency or ability of a liquid or solid material to form a gas at ordinary temperatures. Liquids such as alcohol and gasoline, because of their tendency to evaporate rapidly, are called volatile liquids.

Training Acknowledgment Form

Name		**UOS ID#**		**Building/Lab No.**	
Department			**College**		

I hereby acknowledge that I have received the appropriate training on the below marked topics to work safely in the lab. I have read and understood the training contents.

I also agree to follow all safety practices and procedures that were addressed in the training to keep University of Sharjah a safe and healthy work environment.

	Topic	Date Completed	Signature
☐	**I. Online safety training courses**		
	II. Emergency Plan including:		
☐	1. Evacuation Plan		
☐	2. Location of Emergency Assembly Points		
☐	3. Fire Action		
☐	4. Gas Leak Action		
☐	5. Chemical/Biological Spill Action		
☐	6. Electric Shock Action		
☐	7. Medical Emergency		
☐	8. Location and use of Fire Extinguishers		
☐	9. Location and use of eye wash & emergency Shower		
☐	10. Emergency Numbers at UOS		
☐	**III. CL Safety Policies and Procedures**		
☐	**IV. Your Role and Responsibilities**		
☐	**V. Chemical Hygiene Plan**		

Any other specific training for the lab related activities- Please List:

1- The training records should be kept by the person in charge for all lab workers.
2- The CL Safety Training (Online Safety Training, Safety Manual, Emergency Response Guide, Emergency and Safety Instructions Poster, and Chemical Hygiene Plan) are available on CL Safety Website.
3- For questions or comments please contact Central Labs Safety Officers (Ahmed, Ext# 3428 and Rizwan, Ext: 3416)

8.3 Appendix 3: Risk Assessment Form

Risk Assessment Form

Date: ....

Staff Name: .... Lab No.: .... College: ....

Phone: .... Building No.: .... Department: ....

Category	No.	Hazard/Activity	Who Might be Harmed?	Risk/ Possible Harm	Existing Control Measures to Reduce Risk	Risk Rating			Recommended Control Measures (Further action needed to reduce risks)	Responsible Person	Target Date	Completion Date
						Consequence	Likelihood	Risk Rating				
Chemical Activities	1	Use of hazardous chemicals	Lab staff, students, cleaners	Can cause fires, explosions, skin and eye irritation, cancer, ill health and other serious injuries	*Safety Data Sheets are available for each chemical and the associated hazards of each chemical has been identified *Adequate ventilation is provided (Fume Hood) *All chemicals are used, stored and disposed of in accordance with the Safety Data Sheet or supplier recommendations *Eye, skin and respiratory protection is provided and worn where appropriate and in accordance with the safety data sheet	5	1	Moderate	*Inventory of all chemicals used in the workplace should be prepared	Ahmed	05-12-2017	12-12-2017
	2											

Standard Operating Procedure

For ______________________________

This Template is part of UOS Chemical Hygiene Plan (Appendix# 4) and should be filled by Lab Staff/Lab Faculty Member who is the most knowledgeable and involved in the experimental procedures before carrying out any high risk experiment/research (i.e. working with restricted/highly hazardous chemicals).

SOP Information

Building No./Lab No.		**Date of the SOP**	
Department		**College**	
Written by		**UOS ID No.**	
Approved by		**UOS ID No.**	
Applies to	All faculty, staff, students working with this procedures		

1. Process or Experiment Description:

Description of the process or experiment that the SOP covers. This may be described in
**general procedure, such as. Generic procedure of specific chemical or class of chemicals with similar hazards (e.g. peroxides, organic azides, mineral acids), Generic procedure that covers several chemicals (e.g. distillation process), Working with Lasers, etc.*
**Specific procedure, synthesis of specific Nanomaterial.*

2. Risk Assessment "Review CL risk assessment form and guide on CL Safety Portal"

2.1 Identify Hazards: Identify potential hazards(chemical, physical, equipment, electrical, lasers, etc.)

2.2 Potential risks: Describe the possible harm

2.3 Control of Hazards: Decide on the controls to mitigate the risks.

2.3.1 Engineering Controls: i.e. Ventilation

2.3.2 Administrative controls

2.3.2.1 Special Handling Procedures and Storage Requirements

2.3.2.2 Training Requirements

2.3.2.3 Prior Approval: Identify any tasks that require prior approval by the incharge person and Why?

2.3.3 Personal Protective Equipment

3. Step-By-Step Operating Procedure: Provide a sequential description of work

4. Waste Disposal: What waste products are likely to be produced and how will they be disposed of?

5. Emergency Procedures

5.1 Emergency Equipment

5.2 Spill and Accident Procedures: What steps will be performed if any of the chemicals used are spilled

5.3 Decontamination Procedures: Describe specific cleanup procedures for work areas and lab equipment that must be performed after completion of your process or experiment.

5.4 First Aid Procedures

6. Documentation of Training on the SOP

Prior to conducting any work with the above process/experiment, the lab/project/research incharge must provide training to his/her laboratory personnel specific to the hazards and procedures involved in working with this process/experiment.

The lab/project/research incharge must provide his/her laboratory personnel with a copy of this SOP and a copy of the SDS for all hazardous chemicals.

I have read and understand the above SOP. I agree to fully adhere to its requirements.

No.	Name	UOS ID#	Signature	Date

Revision History

Revision	Date	Description	Reviewed by	Approved by

8.5 Appendix 5: Hazardous Waste List Form

Hazardous Waste List

Date: ....

Lab No.: .... Building No.: .... College: ....

Lab Incharge: .... Phone: .... Department: ....

No	Item's Name	UOM	Qty	Chemicals Waste				Biohazard Waste			State		
				Nature				Nature					
				Flammable	Corrosive	Toxic	Other Plz. Mention	Highly Infectious Group (A)	Infectious Group (C& E)	Sharps Group (B)	Solid	Liquid	Mixed
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

ATTACH MSDS FOR Chemical Waste

*** UOM "Unit of Measure" - e.g. Box, Bag, Bottle, Litres, ml, Kgs, gms,...etc.**

Please mark nature & state appropriately with an "X"

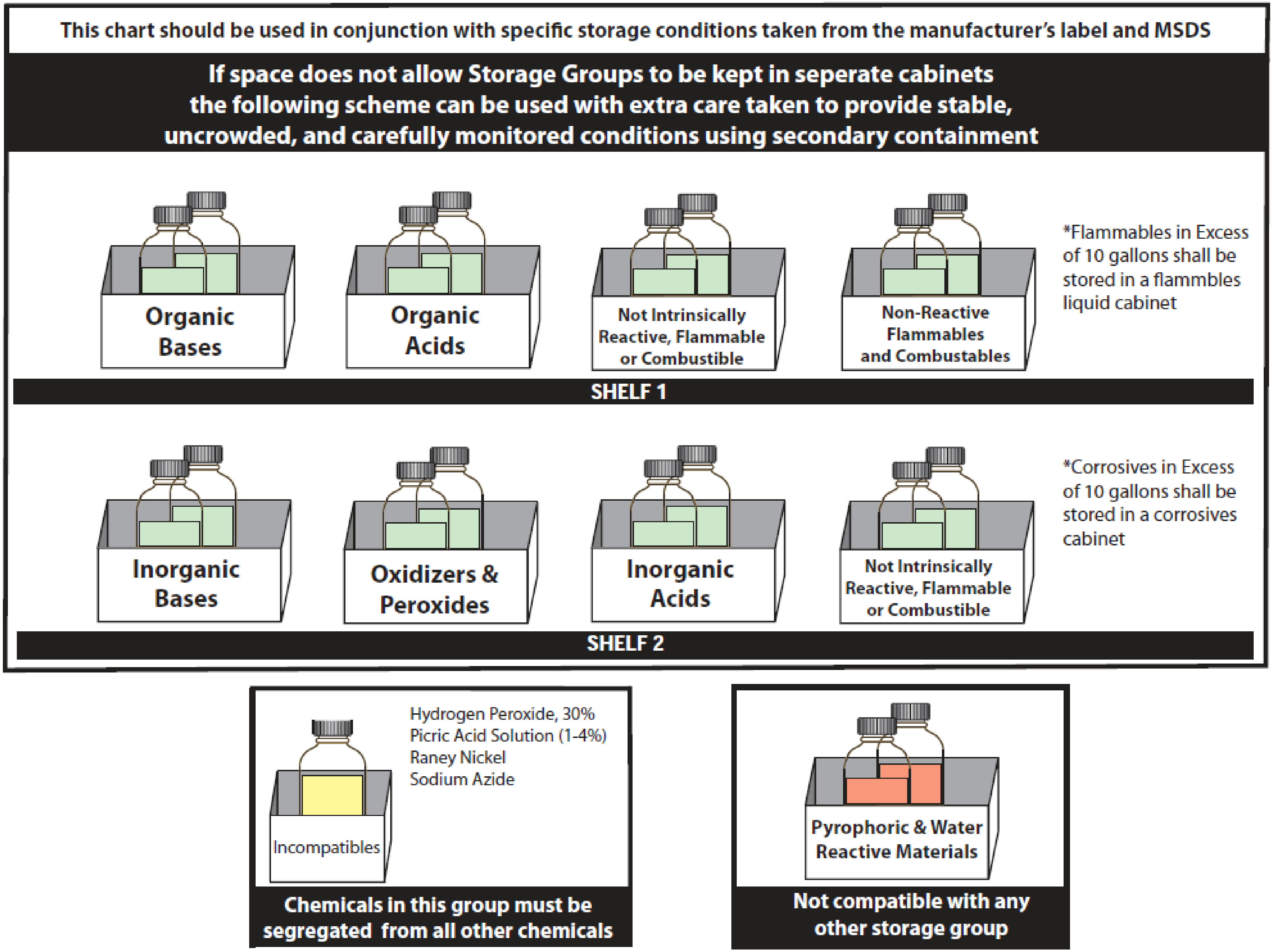
8.6 Appendix 6: Chemical Segregation and Storage Guide

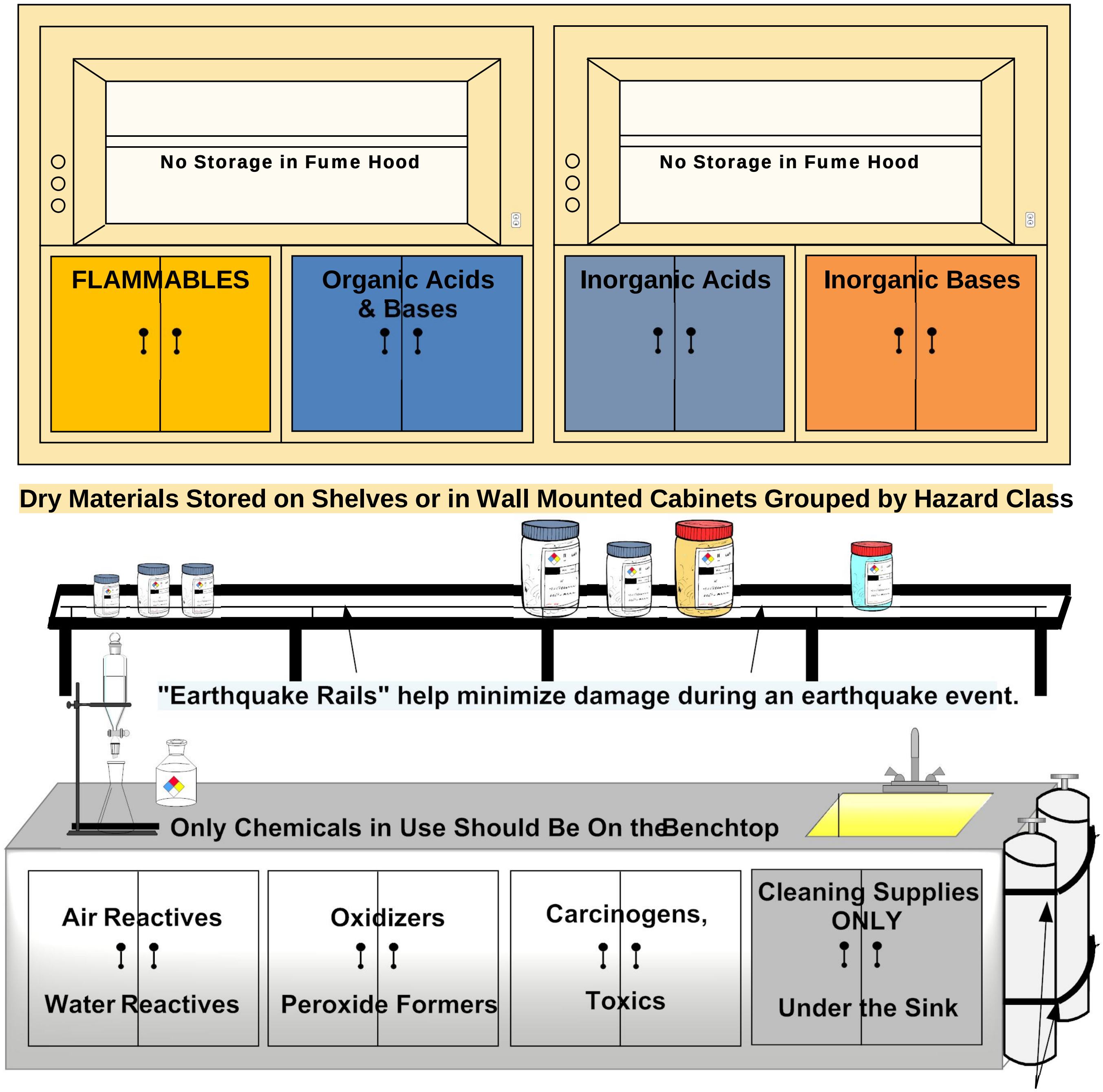
Chemical Segregation and Storage Guide

CLASS OF CHEMICALS and STORAGE GROUP *	RECOMMENDED STORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE MSDS IN ALL CASES
Compressed Gases - Flammable	Store in a cool, dry area, away from oxidizing gases. Securely strap or chain cylinders to a wall or bench top.	Methane, Acetylene, Propane	Oxidizing and toxic compressed gases, oxidizing solids.
Compressed Gases - Oxidizing	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench top.	Oxygen, Chlorine, Bromine	Flammable gases.
Compressed Gases – Poisonous	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench top.	Carbon monoxide, Hydrogen sulfide	Flammable and/or oxidizing gases.
Corrosives – Acids INORGANIC	Store in a separate, lined/protected acid storage cabinet. **DO NOT store acids on metal shelves**	**Inorganic (mineral) acids -** Hydrochloric acid, Sulfuric acid, Chromic acid, Nitric acid.	Flammable liquids, flammable solids, bases, and oxidizers. **Organic acids**
Corrosives – Acids ORGANIC	Store in a separate, lined/protected acid storage cabinet. **DO NOT store acids on metal shelves**	**Organic acids -** Acetic acid, Trichloroacetic acid, Lactic acid	Flammable liquids, flammable solids, bases, and oxidizers. **Inorganic acids**
Corrosives – Bases	Store in a separate storage cabinet.	Ammonium hydroxide, Potassium hydroxide, Sodium hydroxide	Flammable liquids, oxidizers, poisons, and acids.
Explosives	Store in a secure location away from all other chemicals. Do not store in an area where they can fall.	Ammonium Nitrate, Nitro Urea, Sodium azide, Trinitroaniline, Trinitroanisole, Trinitrobenzene, Trinitrophenol/Picric acid, Trinitrotoluene (TNT).	All other chemicals.
Flammable Liquids	Store in a flammable storage cabinet. **Peroxide forming chemicals must be dated upon opening e.g. Ether, Tetrohydrofuran **	Acetone, Benzene, Diethyl ether, Methanol, Ethanol, Hexanes, Toluene	Acids, bases, oxidizers, and poisons.
Flammable Solids	Store in a separate dry cool area away from oxidizers, corrosives.	Phosphorus, Carbon, Charcoal	Acids, bases, oxidizers, and poisons.
Water Reactive Chemicals	Store in a dry, cool location. Protect from water and the fire sprinkler system, if applicable. Label location - WATER REACTIVE CHEMICALS	Sodium metal, Potassium metal, Lithium metal, Lithium Aluminium hydride	Separate from all aqueous solutions, and oxidizers.
Oxidizers	Store in a spill tray inside a non-combustible cabinet, separate from flammable and combustible materials.	Sodium hypochlorite, Benzoyl peroxide, Potassium permanganate, Potassium chlorate, Potassium dichromate. The following are generally considered oxidizing substances: Peroxides, Perchlorates, Chlorates, Nitrates, Bromates, Superoxides	Separate from reducing agents, flammables, and combustibles and organic materials.
Poisons/Toxic	Store separately in a vented, cool, dry, area in chemically resistant secondary containers.	Cyanides, heavy metal compounds, i.e. Cadmium, Mercury, Osmium	Flammable liquids, acids, bases, and oxidizers.
General Chemicals -Non-Reactive	Store on general laboratory benches or shelving.	Agar, Sodium chloride, Sodium bicarbonate, and most non-reactive salts	See MSDS

The segregation chart shown above shall be used at all times. Instances may exist where available storage space is limited and best storage practices may not be used. In those instances, refer to the next pages for alternative storage options.

Chemical Segregation and Storage Chart





Gas Cylinders Securely Chained Preferably With Double Chains on the top and bottom 1/3

Examples:

Flammables: Ethanol, Xylene, Benzene, Methanol, Acetone
Organic Acids: Propionic, Trichloroacetic, Acetic Anhydride
Organic Bases: Hydroxlyamine, Triethylamine, Phenylhydrazine
Inorganic Acids: Hydrochloric, Sulfuric, Stannous Chloride
Inorganic Bases: Sodium Hydroxide, Hydrazine, Potassium Hydroxide
Air Reactives: Titanium Tetrachloride, Red Phosphorus
Water Reactives: Lithium, Sodium, Potassium, White Phosphorous
Oxidizers: Nitric Acid, Permanganates, Peroxides, Chlorates, Nitrites
Peroxide Formers: Isopropyl Ether, Diethyl Ether, Tetrahydrofuran, Dioxane
Carcinogens: Chloroform, Methylene Chloride, Formaldehyde
Toxics: Arsenicals, Cyanides, Methyl Mercaptan
Pyrophorics: t-butyl Lithium, Silane

NTRC NANOTECHNOLOGY RESEARCH CENTER
National Institute for Occupational Safety and Health

Controlling Health Hazards When Working with Nanomaterials: Questions to Ask Before You Start

Here are some questions you should ask yourself before starting work with nanomaterials.

Here are some options you can use to reduce exposures to nanomaterials in the workplace. These options correspond with the questions on the left.

Question	Dry Powder (typically highest potential for exposure)	Suspended in Liquid	Physically Bound/Encapsulated (typically lowest potential for exposure)
(1) FORM Have you done a job hazard analysis? What is the physical form of the nanomaterial? How much are you using? Can you reduce exposure to the nanomaterial by changing its form (for example, putting powder into a solution) or reducing the amount you are using?	**DRY POWDER** (typically highest potential for exposure)	**SUSPENDED IN LIQUID**	**PHYSICALLY BOUND/ ENCAPSULATED** (typically lowest potential for exposure)
(2) WORK ACTIVITY How are you using the nanomaterial? Could the work activity cause exposure? Is the likelihood of exposure low or high? Can you change the way you do the activity to reduce the exposure?	**Applies to Dry Powder Nanomaterials** • Higher potential for exposure: Dumping bags of powder, bagging or sieving of products • Lower potential for exposure: Scooping/weighing of product, transporting containers with light surface contamination or closed barrels/bottles/bags	**Applies to Nanomaterial Suspended in Liquids** • Higher potential for exposure: Spraying, open top sonication, producing a mist • Lower potential for exposure: Cleaning up a spill, pipetting small amounts, brushing	**Applies to Physically Bound/Encapsulated Nanomaterial** • Higher potential for exposure: Cutting, grinding, sanding, drilling, abrasive blasting, thermal release • Lower potential for exposure: Manual cutting and sanding, painting with a roller or brush
(3) ENGINEERING CONTROLS Based on the form and the work activity, what engineering controls will be effective? What are the key design and operational requirements for the control? How does the non-nanomaterial base material or liquid affect exposure?	**Applies to Dry Powder Nanomaterials** • Chemical fume hood • Glove box • Nanomaterial handling enclosure • Ventilated bagging or dumping stations • High-efficiency particulate air (HEPA)-filtered local exhaust ventilation	**Applies to Nanomaterial Suspended in Liquids** • Chemical fume hood • Glove box • Nanomaterial handling enclosure • Local exhaust ventilation • Ventilated spray booth	**Applies to Physically Bound/Encapsulated Nanomaterial** • Chemical fume hood • Glove box • Local exhaust ventilation • Downdraft table • Wet cutting/machining • Ventilated tool shroud • Blasting cabinet
(4) ADMINISTRATIVE CONTROLS Have you considered the role of administrative controls? Have you set up a plan for waste management? Have you considered what to do in case of a spill or how you will maintain equipment?	**Applies to All Nanomaterial Forms** • Establish a chemical hygiene plan • Perform routine housekeeping • Train workers • Use signs and labels • Restrict access to areas where nanomaterials are used	• Handle and dispose of all waste materials (including cleaning materials/gloves) in compliance with all applicable federal, state, and local regulations • Use sealed/closed bags or containers, and secondary containment • Label containers, such as "contains nanoscale titanium dioxide"	• Wet wipe or use a HEPA-filtered vacuum • Do not dry sweep or use compressed air • Incorporate nanomaterial safety into existing programs such as hazard communication
(5) PERSONAL PROTECTIVE EQUIPMENT If the measures above do not effectively control the hazard, what personal protective equipment can be used? Have you considered personal protective equipment for the non-nanomaterial base material or liquid?	**Applies to All Nanomaterial Forms** • Nitrile or chemical resistant gloves • Lab coat or coveralls • Safety glasses, goggles, or face shield	• Respiratory protection when indicated and engineering controls cannot control exposures, and in accordance with federal regulations (29 CFR 1910.134) • NIOSH guidance on respirators can be found at www.cdc.gov/niosh/topics/respirators/	• Use personal protective equipment during spill cleanups and equipment maintenance

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

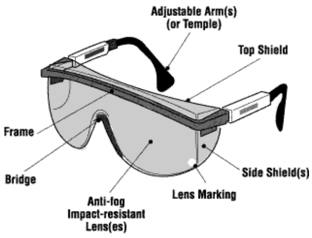
Are you interested in learning more about how you can safely work with nanomaterials or want to stay up-to-date on nanotechnology safety? See the NIOSH NTRC website for more information and links to guidance documents: www.cdc.gov/niosh/topics/nanotech/

DHHS (NIOSH) Publication No. 2018-103 | February 2018
https://doi.org/10.26616/NIOSHPUB2018103

8.8 Appendix 8: Personal Protective Equipment Selection Guide

Applicable PPE	Specific type (example)	Characteristics	Applications
Light latex, vinyl or nitrile gloves	**Disposable latex gloves**	Powdered or un-powdered	Working with biological hazards (known or potentially known infectious materials including work with animals)
	Disposable nitrile gloves 	Puncture, abrasion resistant, protection from splash hazards	Working with biological hazards and chemical splash hazards
	Disposable vinyl gloves	Economical, durable, similar to latex	Working with biological hazards
Light chemical resistant gloves	**Natural rubber latex** 	Chemical resistant, liquid-proof	Working with small volumes of corrosive liquids, organic solvents, flammable organic compounds
Light to heavy chemical resistant gloves	**Nitrile gloves** 	Chemical resistant, good puncture, cut, and abrasion resistance	Apparatus under pressure, air or water reactive chemicals
Heavy chemical resistant gloves	**Butyl gloves** 	High permeation resistance to most chemicals	Large volumes of organic solvents, small to large volumes of dangerous solvents, acutely toxic or hazardous materials
	Viton® II gloves 	High permeation resistance to most chemicals	Same as butyl gloves, plus hazardous material spills
Heavy chemical resistant gloves (cont.)	**Butyl/Silver Shield gloves and apron** 	Extra chemical and mechanical protection	Same as butyl and Viton II gloves, added mechanical protection, hazardous material spills
Insulated gloves	**Terrycloth autoclave gloves**	Heat resistant	Working with hot liquids and equipment, open flames, water bath, oil bath

			
	Cryogen gloves 	Water resistant or water proof, protection against ultra-cold temperatures	Cryogenic liquids handling
Wire mesh gloves		Cut resistant	Working with live animals
Chemical resistant apron	**Rubber-coated wash apron** 	Chemical splash protection, good abrasion resistance	Working with apparatus under pressure, air or water reactive chemicals, large volumes of corrosive liquids
	Neoprene apron and sleeves 	Chemical resistant, tear resistant; splash protection	Water or air reactive chemicals, large volumes of corrosive liquids, small to large volumes of acutely toxic corrosives
Lab Coats	**Knee length lab coats** 	Protects skin and clothing from dirt, inks, non-hazardous chemicals, biohazards without aerosol exposure	General use; Chemical, Biological, Radiation, and Physical Hazards
	Flame resistant lab coat 	Flame resistant (e.g. Nomex or flame-resistant cotton)	Working with water or air reactive chemicals, large volumes of organic solvents, potentially explosive chemicals
	Disposable gowns 	Clothing and skin protection	Working with biohazards

Gowns	**Tyvek gowns** 	High tear resistance, protection from particulates	Working with biohazards with potential for exposure to airborne transmissible disease
Cap	**Bouffant caps** 	Economical protection for hygienic work environments; protection from dirt, dust	Working with biohazards, especially in animal facilities
Shoe Cover	**Disposable shoe covers** 	Protection from dirt, dust; maintenance of hygienic work environments. Adjustable fit, non-skid soles	Working with biohazards, especially in animal facilities
Safety glasses		Polycarbonate lens, side shields for eye protection; meets ANSI and OSHA specifications	**Working with chemical, biological, radiation, physical hazards; laboratory work**
Goggles	**Tight fitting goggles** 	Tight fitting, protects eyes from impact, spray, paint, chemicals, flying chips, dust particles; polycarbonate lens, indirect ventilation, meets ANSI and OSHA specifications	**Working with large volumes of corrosive liquids, small to large volumes of acutely toxic corrosives; working with large volumes of organic solvents, acutely toxic or hazardous chemicals, apparatus under pressure, air or water reactive chemicals**
	Laser Goggles 	Appropriately shaded goggles; optical density based on beam parameters	**Working with Class 3 or Class 4 lasers**
Face shield		Chemical resistant face shield	**For use with mild acids, caustics, aromatic hydrocarbons, methylene chloride; splash hazard; air or water reactive or potentially explosive chemicals**

Safety shield		Acrylic, weighted shield, three sided, benchtop shield, frosted edges	**Protects from chemical splash, beta radiation, exposure to bloodborne pathogens**
Respirators	**Surgical masks** 	Used for bacterial filtration	Working with live animals; working with infectious material with potential aerosol exposure
	N-95 	Protects against dusts, fumes, mists, microorganisms	Working with live animals or infectious materials with known airborne transmissible disease; dusty environments
	Half face 	Air purifying respirator protects against variety of particulates, vapors, dust, mists, fumes; depends on filter cartridge used	Working with live animals or infectious materials with known airborne transmissible disease; dusty environments; chemical vapors; particulates
	Full face 	Same as half- face, but with greater protection factor, and greater protection of eyes and face; depends on filter cartridge used	Working with live animals or infectious materials with known airborne transmissible disease; dusty environments; chemical vapors; particulates
	PAPR 	Air supplying respirator; delivers steady supply of filtered air with loose fitting hoods	Working in BSL – 3 environments; working in dusty environments; chemical vapors, particulates; used when full-face or half –face respirator doesn't fit individual

8.9 Appendix 9: Packaging Requirements for Wekaya

Wekaya' s Health-Care Waste Management Program (Packaging Requirements)

<table>
<tr><th colspan="2">Type of Waste</th><th>Description</th><th>Packaging/Labeling</th><th>Color of Tag</th></tr>
<tr><td colspan="2">Highly Infectious Waste (Group A)
(Waste MUST be sterilized or chemically treated (Sodium Hypochlorite; prior to collection Wekaya)*</td><td>Waste contaminated with; contagious pathogens
➢ Waste foam Isolation wards
➢ Research laboratories
➢ Tissues, (Swabs), equipment that has been in contact with infected patients
➢ Excreta</td><td>➢ Autoclavable bag(PP)
➢ Red
➢ Fill Level=65%</td><td>Red</td></tr>
<tr><td colspan="2">Infectious Waste (Group C and E)</td><td>All waste that came in contact with human blood or fluids is considered as infectious waste.
➢ Pathological Waste
➢ Anatomical Waste
➢ Human Tissue
➢ Used gloves, aprons, masks, shoe and head covers, dressings, bandages, cotton balls, peripads, diapers, cotton swabs, etc.</td><td>➢ LDPE bag
➢ Yellow
➢ Thickness = 100 microns
➢ Fill level = 65%</td><td>Yellow</td></tr>
<tr><td colspan="2">Sharps (Group B)</td><td>➢ Needles, infusion sets, scalpels, knives, blades
➢ Broken glass, etc.</td><td>➢ HDPE yellow Container
➢ Leak Proof
➢ Fill Level= Max. 75%</td><td>Orange</td></tr>
<tr><td rowspan="4">Chemical Waste/Pharmaceuticals
Group D</td><td>Chemical Waste/
(Large quantities of chemical waste should be returned to supplier.)</td><td>Small quantities of chemical waste:
➢ Chemicals are to be accepted ONLY in original container.
➢ Laboratory reagents, film developer, disinfectants, Solvents, etc.</td><td>➢ Inform Wekaya regarding type and quantity.
➢ Send MSDS.
➢ Hold chemical safely until further instructions.</td><td>Blue</td></tr>
<tr><td>Pharmaceuticals</td><td>➢ Pharmaceuticals that are expired or no longer needed, except cytotoxic pharmaceuticals.</td><td>➢ LDPE bag
➢ Yellow
➢ Thickness = 100 microns
➢ Fill level = 65%</td><td>Blue</td></tr>
<tr><td>Wastes with high content of heavy metals</td><td>➢ Batteries, broken thermometers, blood-pressure gauges, etc.</td><td>➢ Same as Pharmaceuticals, but Label clearly as Heavy Metals</td><td>Blue</td></tr>
<tr><td>Cytotoxic Waste</td><td>➢ Expired or no longer needed cytotoxic pharmaceuticals are to be returned to supplier.
➢ Any waste contaminated with cytotoxic products, including excreta from patients like faces, vomit, urine, etc.</td><td>➢ Same as Pharmaceuticals, but label clearly as cytotoxic waste.</td><td>Blue</td></tr>
<tr><td colspan="2">Radioactive Waste (Group F)</td><td>➢ To be returned to the supplier.</td><td>➢ Box made of Lead</td><td>-</td></tr>
<tr><td colspan="2">Municipal Waste</td><td>Aerosols , Domestic Waste, Food Waste, Paper towels for hand washing, paper packaging materials, materials used to clean-up decontaminated or nonhazardous spills.</td><td>➢ Black Bag</td><td>-</td></tr>
<tr><td colspan="5">Based on: Cabinet resolution 37 for the year 2001 "System for the circulation and use of hazardous materials, dangerous and medical waste".
*WHO</td></tr>
</table>

8.10 Appendix 10: Peroxide Forming Chemicals

Peroxide Forming Chemicals

Autoxidation in common laboratory solvents can lead to unstable and potentially explosive peroxide formation. The reaction can be initiated by exposure to air, heat, light, or contaminants. Most of these solvents are available with inhibitors to slow the peroxide formation. Examples of inhibitors include BHT (2,6-di-tert-butyl-4-methyl phenol) and Hydroquinone. There are three categories of peroxide formers:

Class A - Severe Peroxide Hazard: chemicals are those which form explosive levels of peroxides after prolonged storage, especially after exposure to air without concentration. Test these for peroxide formation before using and discard **3 months** after opening.

Class A Chemicals		
Butadiene (liquid monomer)	Chloroprene (liquid monomer)	Divinylacetylene
Isopropyl ether	Tetrafluoroethylene (liquid monomer)	Vinylidine chloride
Potassium amide	Potassium metal	Sodium amide

Class B- Concentration Hazard: chemicals form peroxides that are hazardous only on concentration by distillation or evaporation. Test these before distillation and discard after **12 months**.

Class B Chemicals		
Acetal	Dicyclopentadiene	Methyl isobutyl ketone
Acetaldehyde	Diethyl ether	4-Methyl-2-pentanol
Benzyl alcohol	Diethylene glycol dimethyl ether	2-Pentanol
2-Butanol	Dioxane	4-Penten-1-ol
Cumene	Ethylene glycol dimethyl ether	1-Phenylethanol
Cyclohexanol	4-Heptanol	2-Phenylethanol
2-cyclohexen-1-ol	2-Hexanol	2-Propanol
Cyclohexene	Methylacetylene	Tetrahydrofuran
Decahydronaphthalene	3-Methyl-1-butanol	Tetrahydronaphthalene
Diacetylene	Methylcyclopentane	Vinyl ether

Class C- Shock and Heat Sensitive: chemicals consist of monomers which form peroxides that can initiate explosive polymerization. The peroxides formed in these reactions are extremely shock- and heat-sensitive. Inhibited monomers should be tested before use and discarded after **12 months**. Uninhibited monomers should be discarded 24 hours after opening.

Class C Chemicals		
Acrylic acid	Styrene	Chlorotrifluoroethylene
Acrylonitrile	Tetrafluoroethylene (gas)	Methyl methacrylate
Butadiene (gas)	Vinyl acetate	Vinyl chloride
Chloroprene (gas)	Vinyl acetylene	Vinyl pyridine

Precautions for Peroxide Forming Chemicals

All labs should actively manage peroxide-forming chemicals and follow the following practices:

1. Date all peroxidizables upon receipt and opening. Unless the manufacturer has added an inhibitor, materials should be disposed of in a timely manner.
2. Periodically test contents for peroxides using peroxide test strips; record test date and results on container. A common test used is the MQuant™ Peroxide Test Strip (0-100 ppm range). Available through Sigma Aldrich Catalog # 1100810001. If the test results are:

< 25 ppm	Considered safe for general use
25-100 ppm	Not recommended for distilling or otherwise concentrating
>100 ppm	Avoid handling and contact CLD for proper disposal

3. Do not open any container with evidence of peroxide formation such as obvious crystal formation around the lid or in the liquid, or visible discoloration.
4. Keep peroxide-forming chemicals in their original containers to minimize conditions that accelerate peroxide formation.
5. All peroxide forming solvents should be tested prior to distillation.
6. Other precautions are similar to those used for flammables.

Emergency Numbers  أرقام الطـــوارئ

UOS Security الأمن الجامعى

050 586 8063 (24h)
Ext No. 3024

Ambulance إسعاف الجامعة

050 527 2233 (Women)
050 161 9365 (Men)

Maintenance Department إدارة الصيانة

Ext No. 5555 (06 505 1555)

Electricity (Saheb)	**050 547 8423**	**الكهرباء** (صاحب)
Maintenance (Ehab)	**055 788 0509**	**الصيانة** (إيهاب)
AC (Aabid Ali)	**052 948 6110**	**التكييف** (عابد على)

Safety Office مكتب السلامة
Central Labs المختبرات المركزية

Ahmed	**Ext No. 3428, 050 105 6540**	**احمد**
Rizwan	**Ext No. 3416, 055 708 9239**	**رضوان**

Civil Defense الدفاع المدني

997

University City Police شرطة المدينة الجامعية

06 505 9555

Police **999** **الشرطة**

Online Chemical Inventory Management System Policy & Procedure

	Prepared By	Reviewed By	Approved By
Name	Eng. Mahmoud Abu Shammeh	Dr. Hussein EL Mehdi	Prof. Hamid M.K. Al Naimiy
Designation	Director, Central Laboratories Directorate	Dean, Academic Support Services	Chancellor, University of Sharjah
Signature			
Date			

PROCEDURE #: UOS/CLD/SS/13

TITLE: **Online Chemical Inventory Management System Policy & Procedure**

PURPOSE: To describe the policy and procedure for Management of chemicals Inventory for all labs fall under jurisdiction of Central labs Directorate, University of Sharjah.

SCOPE: This procedure applies to all labs comes under Central Labs Directorate, University of Sharjah.

REFERENCE:

- OSHAD-SF, Ver-3; May 2017; Clause-5.2 (Chemical Hazards)
- Other applicable policies and procedure of Central Laboratories Directorate
- ISO 14001:2015, Clause: 8.1 (Operational Planning and Control)
- ISO 45001:2018, Clause: 6.1 (Actions to address risks and opportunities), Clause: 8.1 (Operational planning and control), Clause: 8.2 (Emergency preparedness and response)
- Central Labs Chemical Hygiene Plan 2019.
- Central Labs Lab Safety Manual 2020.

ABBREVIATION:

CLD – Central Laboratories Directorate

DCLD - Director Central Laboratories Directorate

DASS - Dean of Academic Support Services

LSO: Lab Safety Officer

LS- Lab Staff: (Lab Supervisors, Lab Officers, Lab Engineers, Clinical Tutors, Lab Technicians and Research Assistant)

LFM- Labs Faculty Member (Professor, Associate Professor, Assistant Professor, Lecturer and Researchers)

FMPD- Facilities Management & Planning Department
PI- Principle Investigator (LS or LFM)
GU- General User (LS or LFM)
TST- Technical Support Team
CIMS- **Chemical Inventory Management System**

Chemical Inventory Management System Policy

Lab Staff and Labs Faculty Member who use or store chemicals at University of Sharjah, are required to maintain an accurate and update chemical inventory for their laboratories regularly through the Central Labs Chemical Inventory Management System (LabcliQ) , in order to enhance labs safety, efficiently utilize the available chemicals, comply with the Local Regulations and provide critical information to responders during an emergency.

RESPONSIBILITY		ACTION
	1.0	**Online Chemical Inventory Management System**
	1.1	The Chemical Inventory Management System (LabcliQ) is a cloud-based software used to manage, identify, track and maintain chemicals in all locations at the University of Sharjah. **Note:** 1. You can access the Chemical Inventory Management System from the Central Labs portal link below: https://myuos.sharjah.ac.ae/en/Pages/CL.aspx 2. You can read the User Guide for CIMS from the Central Labs Safety portal link below: https://myuos.sharjah.ac.ae/en/Pages/CL_Safety.aspx The user guide includes: • Viewing Chemical Inventory • Searching and Filtering the Inventory • How to Add/Edit/Dispose Chemicals • Replacing and Transferring Chemicals • Exporting your Inventory
	2.0	**Add/Edit/Dispose Chemicals on CIMS**
LS, LFM	2.1	All teaching and research chemicals brought onto University of Sharjah must be entered into the Chemical Inventory Management System (LabcliQ) upon initial receipt.
LS, LFM	2.2	Ultimately responsible for ensuring that chemical containers under their control have been updated on the CIMS after any new changes on the container (dispose, transfer, replace, etc.).
LS, LFM	2.3	The inventory must include a full chemical name, CAS number, amount of the chemical with suitable units of measurement, physical state, product number, Lot No., owner, and room number, and Additionally, the expiration date must be added if it is available on the chemical.
LS, LFM	2.4	Chemical owner must dispose chemical container once it consumed completely and keep chemical inventory updated.

LS, LFM	2.5	Don't receive chemicals which are near to expire, unless you are sure to consume chemical before expiry, to avoid storing expired chemical in labs/storerooms.
	3.0	**Request of Transfer/Borrow Chemical from Another Owner (within department and outside department)**
LS, LFM	3.1	If you need a small quantity of chemical or complete chemical container from another lab within department or outside department from different chemical owner, then send require chemical container details to Central Lab Technical Support Team by email. You can export the details of the required chemical in excel format and send it by email to TST **Note:** No other LS and LFM can take your chemicals without your prior approval. Central lab technical support team will first take approval from chemical owner. If he/she agree to give the chemicals to the requester, then the request will be approved.
	4.0	**User Access Controls**
LSO	4.1	**Administrator privileges:** • Have full access and control to the entire database. • Can do all changes or necessary amendments (if require). • Adding new users to the CIMS • Ensures the system is working fine • Support lab staff or LFM in case of any problem encounter. • Monitoring the CIMS and report any nonconformity to Director of Central Labs.
LS, LFM who own chemicals	4.2	**Principal Investigator Privileges:** • Adding new chemicals. • Editing his/her own chemicals. • Disposing his/her own chemicals. • Replace existing chemicals with new ones. • Transfer chemical to another owner. • Transfer chemical to another location/lab under his/her name. • View only the entire UoS Chemical Inventory without editing/disposing/replacing/transferring the other owners' chemicals • Can give access to lab employees who are working for his/her lab by sending an official request to system administrators (LSO).
LS, LFM who don't own chemicals	4.3	**General User Privileges:** • View only the entire UoS Chemical Inventory without editing the other owners' chemicals

CL Technical Support Team	4.4	CL Technical Support team will have access as a general user account to: • View only the entire UoS Chemical Inventory • Verify the chemical inventory details for each chemicals requisition, prior to send it to procurement department. • In case of purchase request of small amount of chemical, they can borrow this amount from the chemical owners with prior approval from his/her end. • Communicate with chemical owners and get approval to borrow or transfer chemicals.
	5.0	**Monitoring and Control**
LS, LFM	5.1	Ensure your chemical inventory are updated after any changes.
LS, LFM	5.2	Verify and update the chemical inventory against the physical stock annually, recommended before starting your summer vacation (by end of June).
LSO	5.3	Report any noncompliance to DCLD, and takes appropriate action as deemed necessary.
	6.0	**Records**
CLD	6.1	• Inventory database is available online all the time

7.0 REVISION HISTORY

Revision	Date	Description	Prepared By	Reviewed By	Approved By
00	01-11-2019	Online Chemical Inventory Management System Policy & Procedure	Director CLD	Dean Of DASS	Chancellor

ENERGY MANAGEMENT POLICY AND PROCEDURE

1. Energy Efficient Appliances and Constructions

The University of Sharjah started purchasing Energy-Efficient equipment to minimize energy consumption, such as:

- ✓ Use of LED lighting with daylight/motion sensors to eliminate the need for artificial light in the presence of daylight as well as to minimize the use of light when not required.
- ✓ Use of Low window to wall ratio in the building design to minimize heat ingress into the buildings along with sensor-based doors and windows.
- ✓ Use of Low VOC paints / lighter coloured roofs to reflect the solar heat gain and reduce heat load and increased cooling.
- ✓ Use of Double Glazed doors and windows to inculcate passive design technology.
- ✓ Purchase energy-efficient computers, laptops and printers for the offices, housing and dormitories to reduce plug load consumption.


Figure 1: LED lighting

1.1. Energy-Efficient Computers and Laptops

New OptiPlex 7060 Small Form Factor

Environmental Standards (eco-labels)
ENERGY STAR
EPEAT Registered*

Figure 2: Computers

1.2. Energy Efficient Printers

Environmental Standards (eco-labels)
ENERGY STAR
EPEAT Registered*
TCO Certified
CEL
WEEE
Japan Energy Law
South Korea E-standby
South Korea Eco-label
EU RoHS
China RoHS*

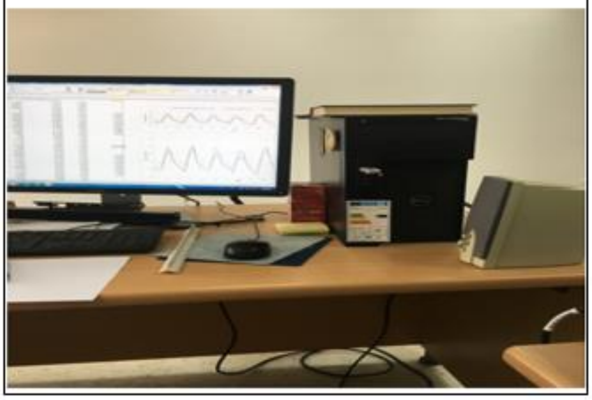


Figure 3: Printer

1.3. Energy Efficient Refrigerators

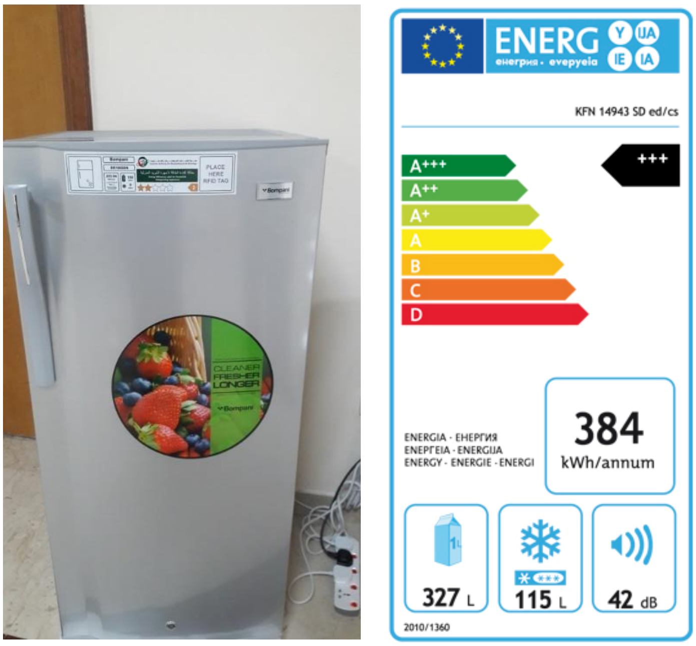


Figure 4: Refrigerators

1.4. Automatic Doors – To reduce the cooling load of the building

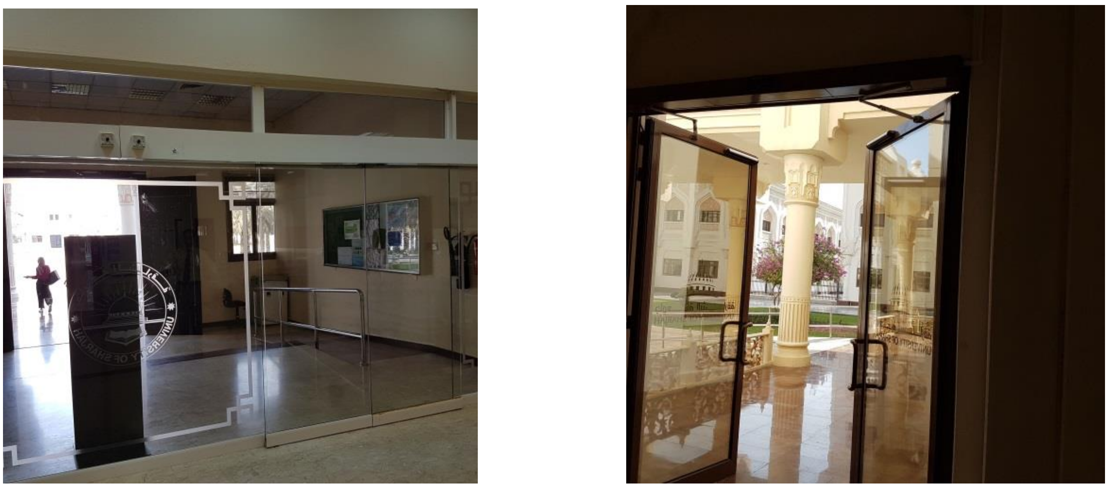
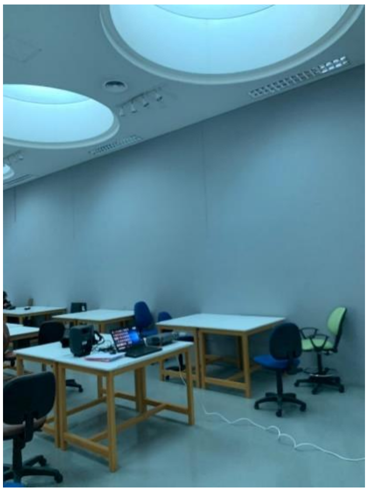


Figure 5: Automatic Doors

1.5. Natural light to reduce the consumption of energy



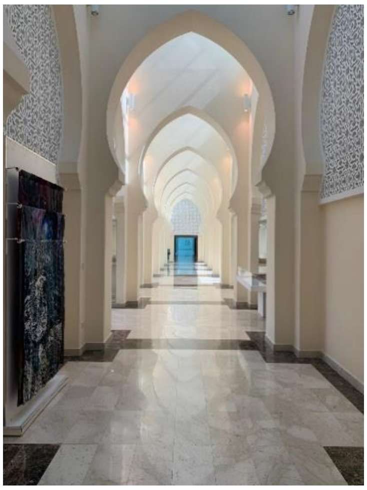



Figure 5: Natural lights

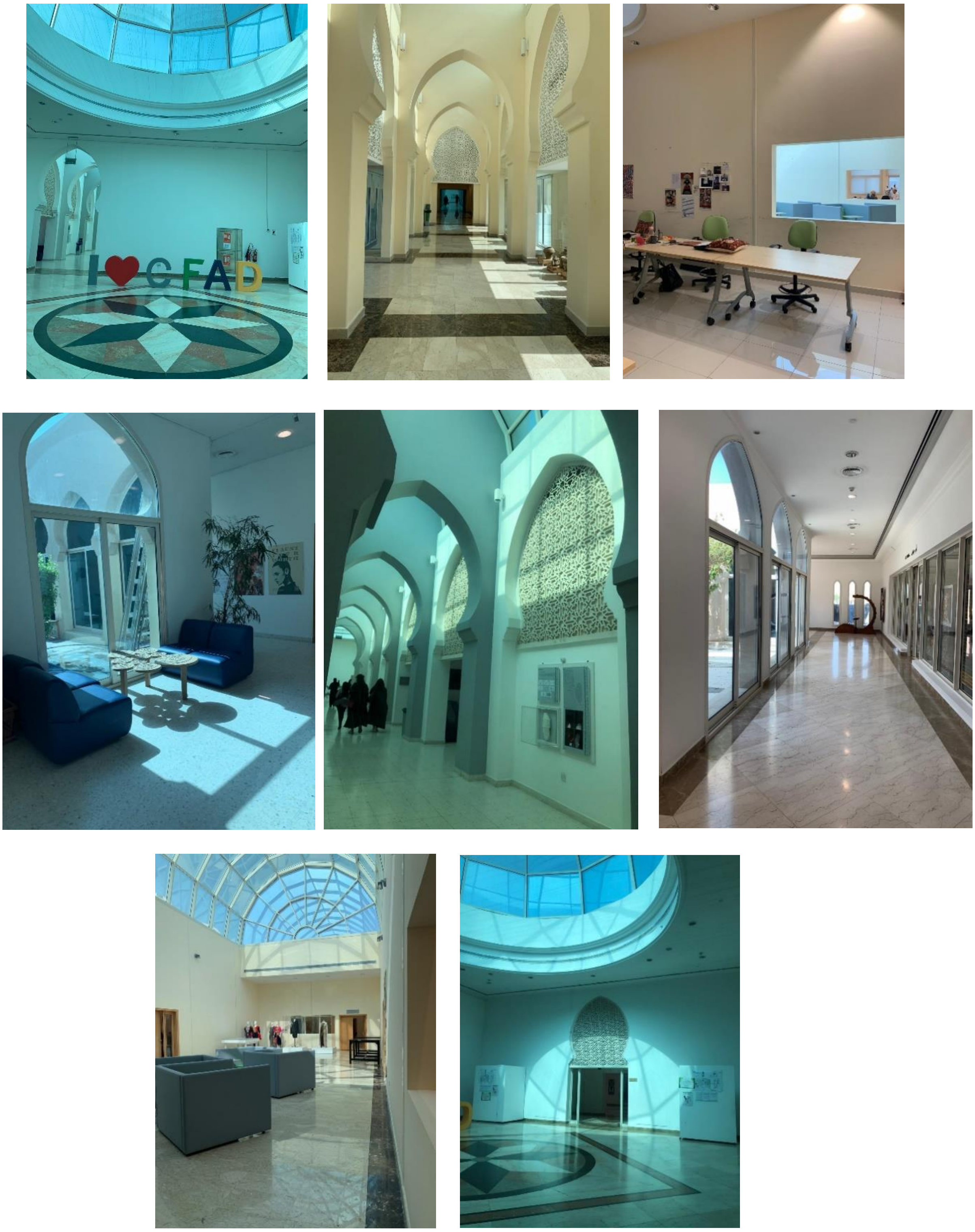


Figure 5: Natural lights (continued)

2. Energy Performance Contracting

University of Sharjah (UOS) issued a request for proposal (RFP), Contract Number: SC18/5, soliciting bids from 2 prequalified Energy Services Company (ESCOs) to develop an Energy Performance Contract (EPC) for the main campus.

The two prequalified ESCOs are:

- Siemens
- Johnson Controls (JC)

The aim is to identify the best possible project concept that would result in the highest potential annual guaranteed savings within an 8-year payback period to minimize the yearly energy consumption by 40-45%. Following this RFP, the University will sign a guaranteed-savings EPC with the ESCO providing the best technical and commercial proposal. To help select the best ESCO, an assessment of the two prequalified ESCOs' bids will be made to move forward to an investment-grade audit and the implementation stage.

3. Smart Buildings to Reduce Energy Consumption

The University is launching a new system to save the energy within the whole educational campuses, which includes the utilization of day-time light sensors, motion sensors, smart doors, along with passive tools of energy-saving like double-glass windows, among others. The installed sensors are motion/daylight sensors that have been added in all open corridors at the university campuses. These sensors help in reducing energy consumption by switching ON the artificial lighting only in the presence of motion. Also, in the presence of natural daylight, the sensor detects the available lighting lux levels and keeps the artificial lights OFF. The total main campus smart building area is 7945 m^2.

Figure 6: University of Sharjah Solar House

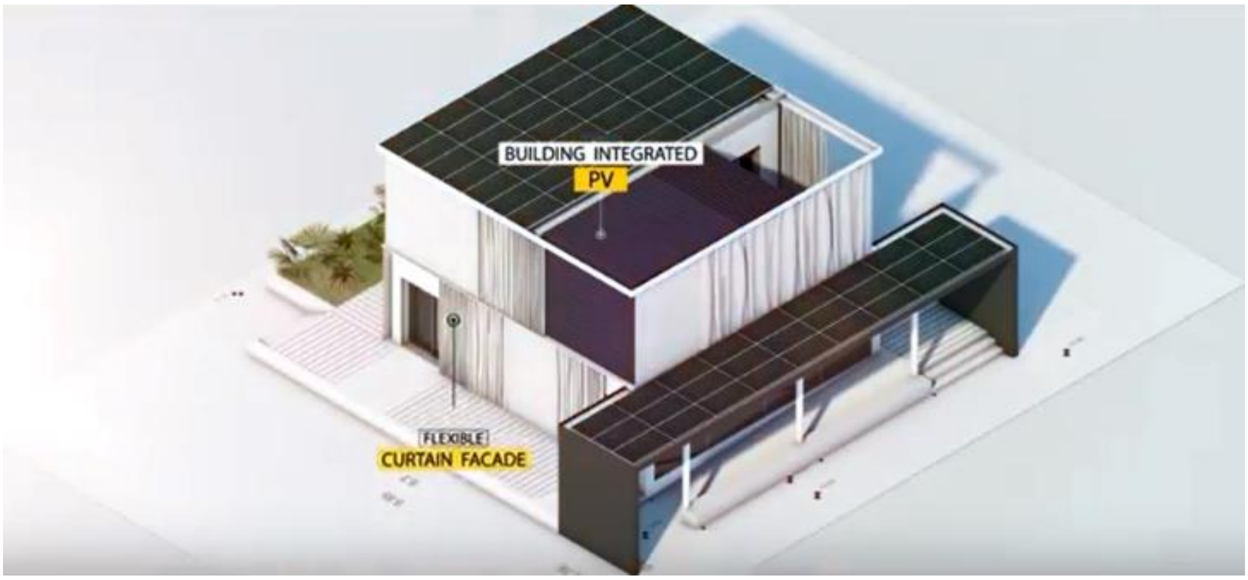


Figure 6: University of Sharjah Solar House (continued)

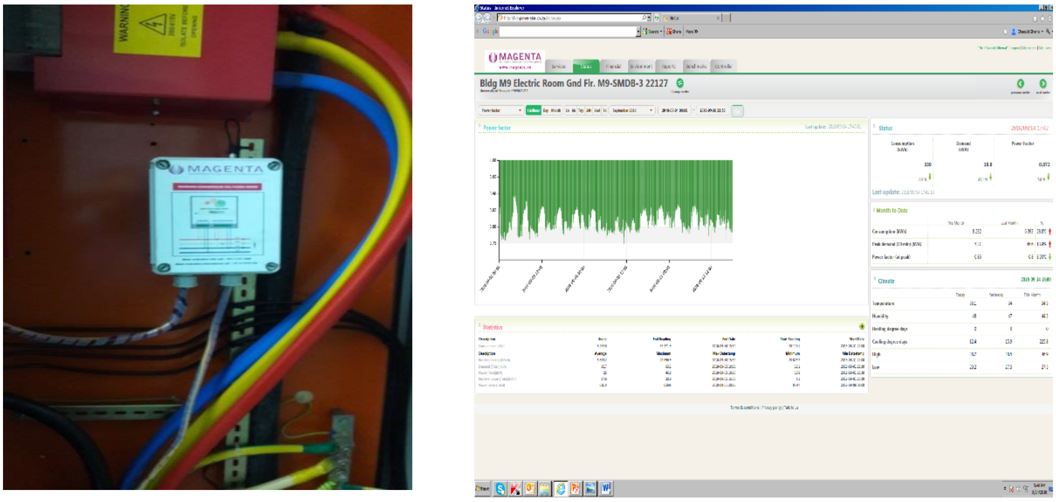


Figure 7: Smart Meter – M9 Building

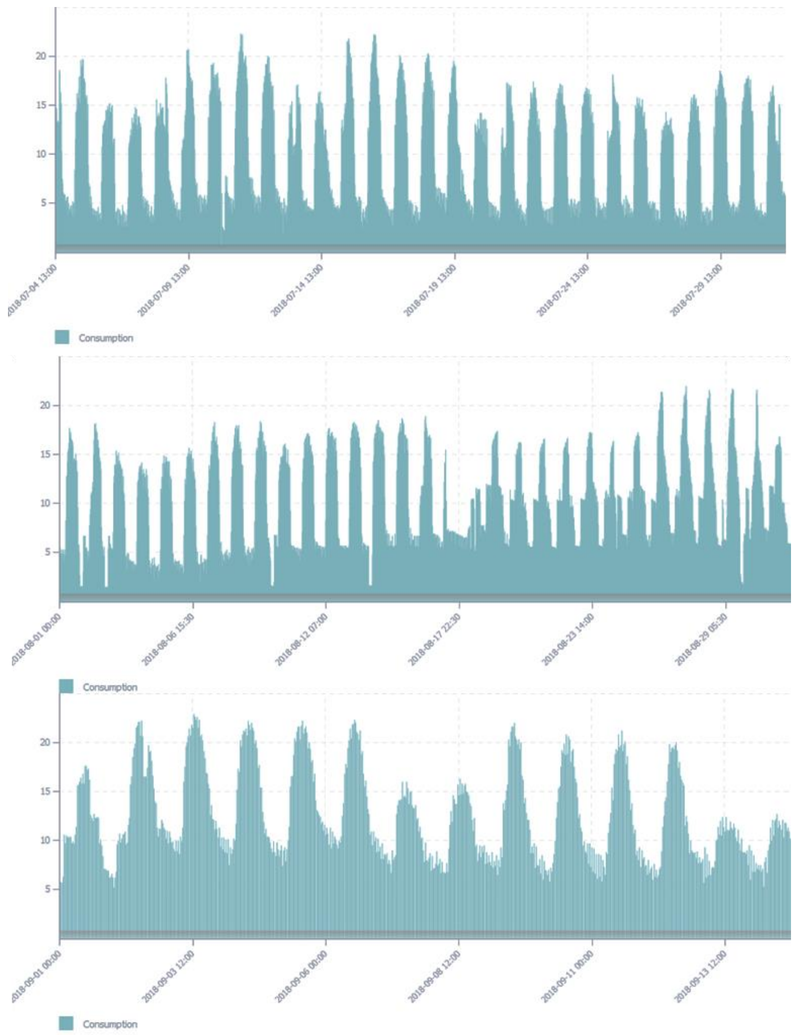


Figure 8: Energy Consumption – M9 Building

Figure 9: Sharjah Center for Astronomy and Space Sciences – University of Sharjah

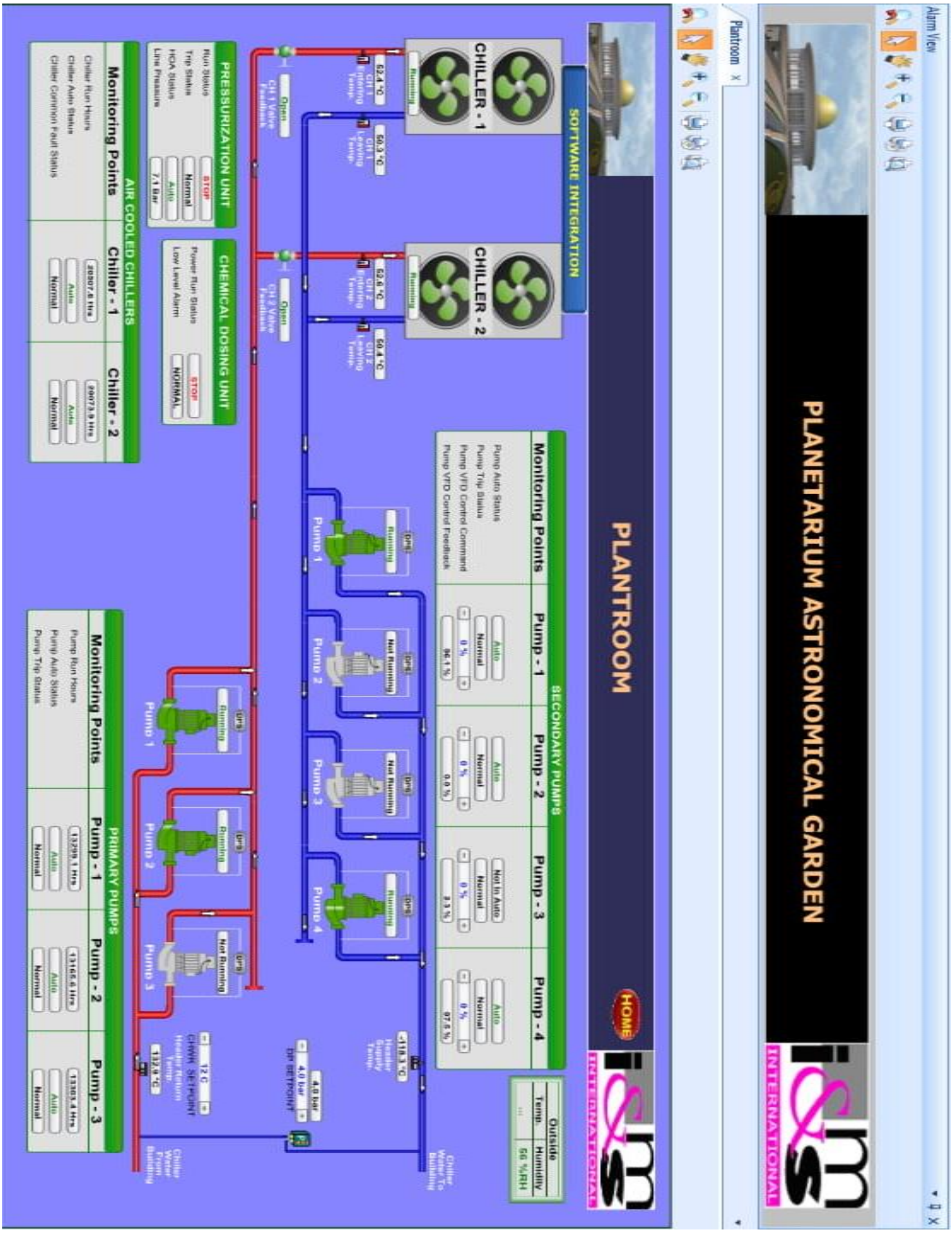


Figure 10: Building Monitoring System (BMS) for Sharjah Center for Astronomy and Space Sciences – University of Sharjah

Figure 11: Control room of Building Monitoring System

Figure 12: Several screens showing the operation of the new Building Monitoring System

Figure 13: Picture showing the Building Monitoring System while it is functioning

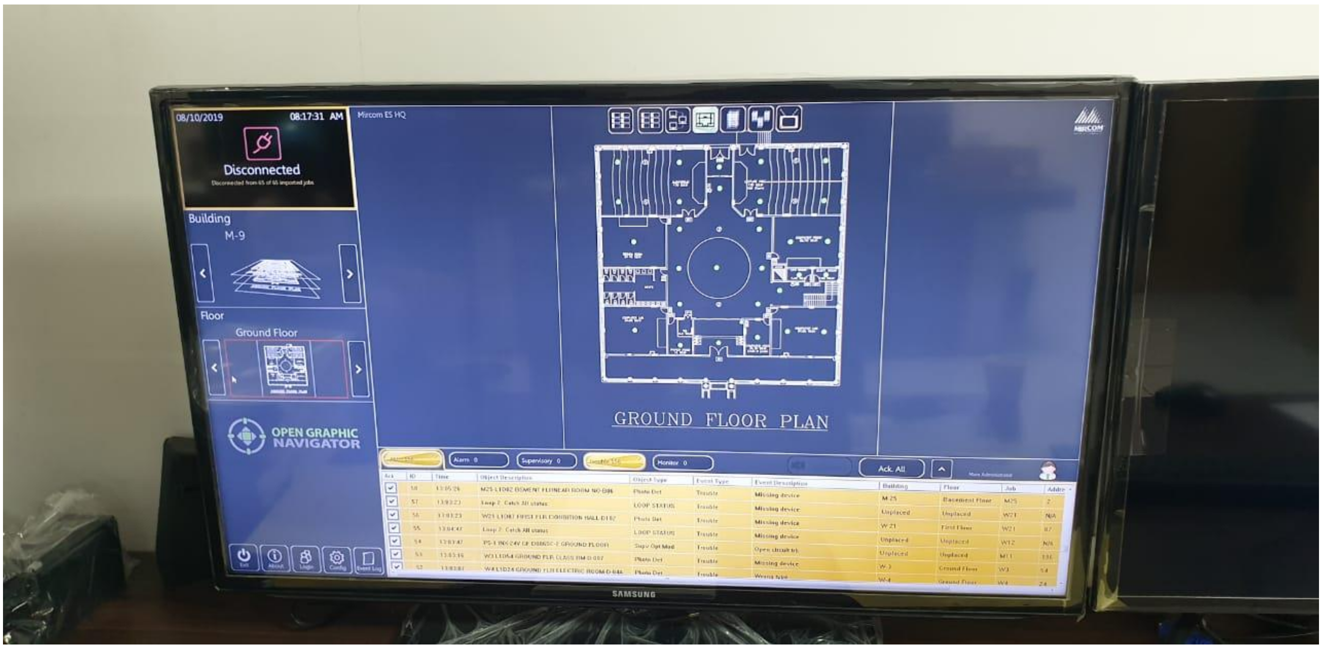


Figure 14: A screen showing the ground floor of one building with the locations of sensors

Figure 15: Smart doors

Figure 16: double-glazing windows

Figure 17: Motion sensors for lighting

4. Renewable Energy Produced Inside the Campuses

Figure 18: 10 Tones (35 kW) Solar Air Conditioning System

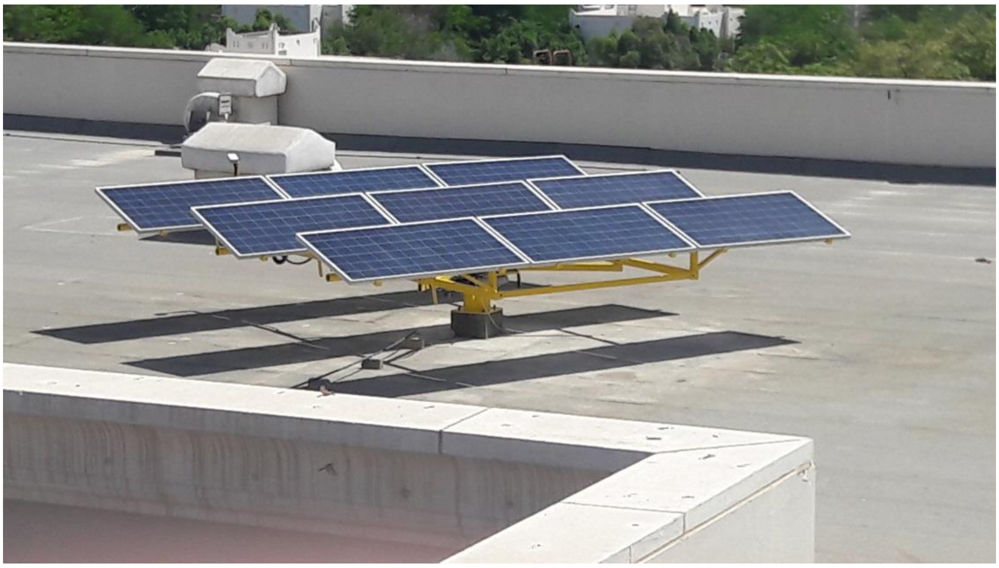


Figure 19: Solar PV (3 kW)

Figure 20: Solar PV for Efficient Building – 1.5 kW

Figure 21: Solar PV Panels

Figure 22: Batteries and Controller, Solar PV for Golf Cart Charging (1.5 kW)

Figure 23: 9.6 kW – University of Sharjah Solar House

Figure 24: Solar PV (2.52 Kw) Powered Green House – University of Sharjah

Figure 25: Hybrid Solar PV/Wind Energy system (800 W)

Figure 26: Biomass Gasifier – 20 kW