Safety Manual

College of Engineering

United Arab Emirates University

Revised and Edited

by

Prof. Samir I. Abu-Eishah

April 2021

Acknowledgment

The College Safety Committee wishes to express their gratitude to the Dean of the College of Engineering for giving them the opportunity to revise and update this Safety Manual and for his support and encouragement. Thanks also goes to Laboratory Staff who voluntarily participated in implementing the Committee Recommendations before and within the revision period of this Manual.

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INTRODUCTION

1. INTRODUCTION

1.1 Dean's Assignment (2015)

Dear Colleagues; Members of the College Safety Committee

On behalf of the Dean of the College of Engineering who assigned the College Safety Committee to revise and update the 2003 College Safety Manual. You may choose the part mostly relevant to your department and labs and update and/or modify that part (plus any other part you may be interested to do so).

Please make sure that all safety issues for your department labs are strictly adhered to the new Abu Dhabi and UAE Safety/Health Regulations. The first revision of the 2003 Safety Manual was made by the Safety Committee in 2015.

Best regards,

Prof. Samir Abu-Eishah,

Chair, COE Safety Committee

1.2 College Safety Committee

The **College Safety Committee** is formed by a decree from the Dean and has a representative from all the College academic departments.

Among the duties of the College Safety Committee are:

- Review safety procedures and the safety of activities in the instructional and research laboratories and other facilities as appropriate.
- Search for innovative ways to improve the safety regulations and rules.
- Report any deficiencies to the Dean and Departments' Chairs.

The College Safety Manual, was originally prepared in 2003 by a sub-committee composed of Prof. Abdurazak Zekri (PE), Dr. Abdel-Hamid I. Mourad (ME), and Dr. Munjed Maraqa (CEE). The Safety Manual was revised and updated in 2015 by the College Safety Committee composed of Prof. Samir I. Abu-Eishah (CHE), Dr. Timur I. Mauga (CEE), Dr. Muhammad R. Ramzan (EE), and Dr. Ayman Abu Hammad (AE).

The last update has been made in 2020 by Prof. Samir I. Abu-Eishah (the Committee Chairman) and presented under **Section 1.6 The 2020 Safety Manual Updates**.

The College Safety Manual is considered as a reference manual for the College of Engineering. It covers procedures and practices to be followed in order to ensure a safe and healthy environment at the College of

Engineering. The goal of the College of Engineering is to comply with all environmental regulations and nationally recognized codes and standards. This manual is developed to foster safe work habits as well as maintaining a safe work environment.

The Safety Manual is available online for staff, faculty and students as well.

1.3 Responsibilities

All UAE University employees (i.e., Faculty, Graduate Students, Technicians, Lab Engineers, etc.) as well as students are responsible and accountable for safety performance and environmental protection as outlined in this manual. Faculty, staff, and students are responsible for the following:

- Performing their jobs in the safest prescribed manner.
- Eliminating and/or reporting workplace hazards.
- Reporting accidents, incidents, and unsafe practices or conditions to the Head of Department.
- Ensuring proper disposal of or transfer of all hazardous materials before leaving the University.

1.4 Preface

Reasonable precaution should be taken in the performance of work at the United Arab Emirates (UAE) University to protect the health and safety of staff and students and to prevent property damage. A healthy and safe environment is critical to promote and achieve excellence in teaching and research. Establishment of such an environment necessitates an effective early identification and understanding of safety issues, development of appropriate control measures, implementation of these controls through specialized training, and monitoring the effectiveness of the controls.

This Safety Manual is a guide toward the achievement of a safe and healthful work and study environment at the College of Engineering. It describes widely accepted standards and guidelines that should be followed to keep laboratory accidents to a minimum. Cooperation among all is necessary, and it is the expectation that each will share the responsibility of implementing the applicable guidelines to upgrade the safety in our laboratories.

The Safety Manual contains 11 Chapters and several Appendices and Forms followed by References. The subject is introduced in Chapter 1. Chapters 2 and 3 deal with (Emergency Situation) and (Emergency Procedures). Chapters 8 (Fire) and 9 (Electrical Safety) are possibly relevant to all workers in the College of Engineering. Chapters 4 (Safety Rules), 5 (Chemical Hazards) and 10 (Hazardous Waste Disposal) are specifically prepared for employees dealing with chemicals. Chapter 6 (Biological Hazards) is prepared for workers dealing with or could possibly be exposed to bio-hazardous materials. Chapter 7 (Mechanical Safety) should be relevant to workers in the several Departments within the College of Engineering. Please take few minutes to read the contents of this Safety Manual and decide which part you need to read and understand for your safety and the safety of others with whom you are working.

1.5 To the Lab Engineers and Lab Technicians

The lab engineers and the lab technicians are the key to maintaining a positive safety attitude in the laboratory. The trick is to encourage laboratory safety without creating a fearful climate. Successful lab exercises rely on everyone taking responsibility for safety:

- ➢ Know the safety procedures, potential hazards and precautions for each experiment before teaching or conducting a laboratory exercise.
- ➢ Know the location and operation of emergency equipment, what emergency procedures are appropriate and how to summon assistance if needed.
- ➢ Understand the chemical hazards and precautions specified in the pertinent Material Safety Data Sheets such as, for example, the one used at Texas A&M: http://www.bio.tamu.edu/USERS/TONNA/CHEMICAL.HTM
- ➢ Explain each experiment and alert others to possible hazards before they begin the laboratory exercise.
- ➢ Foster a serious attitude toward lab content and safety. Supervise students closely while encouraging respect for safety.

1.6 Latest Updates of the College Safety Manual

Khadamat Facilities Management, the joint venture company operating the UAEU Campus, has the responsibility for health and safety issues. The Khadamat company combines the investment and development skills of Mubadala Development Company and the facilities management skills of Serco, a leading global service company. Khadamat, along with the UAEU Facilities Development Department (formerly called 'Campus Development Department'), provide instructions and guidelines for major risk preventions, including fire, security, timetabling, waste management, cleaning and emergencies. The accident reporting system provides a log of all accidents and complaints 24/7. Evacuation procedures are in place and Fire Evacuation Coordinators are designated across the campus. Procedures are practiced regularly by Khadamat: several fire drills (and emergency evacuation drills) are conducted every year.

The campus is fully accessible, including buildings. Handicapped students are usually met at the main gates by electric campus vehicles and transported to the buildings for classes or services. The campus has handicapped toilet facilities throughout. The residence has halls that are handicapped accessible. There two well-equipped clinics for male and female campus that are run with cooperation with NMC Speciality Hospital.

A comprehensive Risk Management Policy has been developed at the UAEU. The policy stipulates assignment of a Risk Manager responsible for ensuring that potential risks to health and safety, are identified and addressed in accordance with the Risk Management Policy and Risk Management Procedures.

The College Safety Committee is comprised of safety coordinators of the College Academic Departments. Also, each Department has its own safety committee. These committees oversee the proper adherence to the University Safety Policies and Procedures, and recommend improvements and purchase of needed safety equipment. The College Committee has unannounced visits to the college laboratories every semester to make sure that all safety measures and procedures are followed in accordance with the College Safety Manual, which is available at the College of Engineering Website.

The UAEU campus was built with the state-of-the-art laboratories that are shared by both male and female students, on a time-segregated system. The labs are managed and supervised by specialized lab engineers and technicians. Each lab is supervised by an assigned faculty member or a staff as supervisor, responsible for enforcing the safety rules and proper lab operation.

The total net laboratory space available for the College of Engineering is 10,900.44 m^2. The laboratory spaces do not include preparation rooms, technician rooms and other amenities. In order to serve both educational and research needs, the labs are well equipped with appropriate experimental setups, physical models, safety measures, and devices for the various courses. New equipments are continuously bought and added to the labs to achieve the students' outcomes and support the programs' educational objectives. The labs are regularly maintained and upgraded.

The University has an annual budget process. Each college estimates its needs for materials and equipments to support its laboratories as part of this budget. The college departments have their annual operational budgets for the labs' materials, equipment and maintenance. The budget process is linked to the UAEU 3-year strategic plan. Furthermore, colleges are annually asked for additional equipment and material needs, which can sometimes be met centrally, using savings that accrue through the academic year.

Faculty members, instructors, lab engineers, and lab technicians continuously raise students' awareness on safety issues. Safety instructions are hanged on the walls. Material Safety Data Sheets (MSDS) are placed on benches near running experiments. First aid kits are available in all labs. Safety guidelines are prepared and regularly updated by the College Safety Committee. The students are provided with appropriate guidance regarding the use of the tools, equipment, computing facilities, and laboratories at two levels. At the primary level, help is provided through lab instructions and tutorials run by the lab engineers, technicians and faculty members. At the secondary level, help is provided by lab engineers, instructors and faculty members in the form of on-spot help and assistance.

The lab engineers and technicians are responsible of installing, preparing, and maintaining lab equipment. The lab engineers are available during lab sessions to help instructors and faculty members teaching the lab courses. They are also available to provide guidance to students in their course term projects and graduation projects.

As a requirement of the Civil Defense Abu Dhabi, a chemical inventory was established for each laboratory in the E-Series in 2011 (end)/2012 (beginning). The inventory used NFPA classification (NFPA diamond – classification 0-4) to categorize the chemicals as to their hazard.

More details on Safety Issues at the UAEU can be found in the Master Thesis (2019), which is available at and can be downloaded from:

https://scholarworks.uaeu.ac.ae/cgi/viewcontent.cgi?article=1007&context=bio_theses

This reference gives details about the following topics:

- UAEU E-shared Laboratory Series,
- Health and Safety Policy,
- Health and Safety Organizational Structure,
- Health and Safety Guidelines for the E-shared Laboratories,
- Radioactive Materials, Radiation Sources and Nuclear Material,
- Chemical Inventory and Storage of Chemicals in the E-shared Laboratories,
- Shifting to Safer Chemicals – Sorting out Materials of Exceptional Hazard,

- Waste Collection, Waste Streams and Waste Management,
- Risk Assessment and Audit, and others.

Laboratory Safety Induction

A safety session is given for the students each semester for every lab course. This represents the first lab unit in each lab course. Often, the laboratory instructor gives a safety quiz to the students. Students, faculty and employees have been urged to watch the "Laboratory Safety Induction" video in "OHS Induction Course" on Blackboard or at https://youtu.be/pIWTOnE3aL8?t=26

The Combination of getting vaccinated & practicing protective behaviors, such as self-hygiene, physical distancing, self-quarantine, avoidance of mass congregations, use of personal protective equipment will offer the best protection from COVID-19.

Lab Reopening Safety Inspection Checklist Form

A Lab Reopening Safety Inspection Checklist Form has been issued and distributed by the University as a pre-check (inspection) for general and COVID-19 measures prior to reopening of any University lab. Faculty members and staff were asked to fill the form and send it to OHS Facility Management Office for review. Additional lab preparations and safety measures have to be fulfilled prior to any lab reopening or resuming any research work in it.

Review and Evaluation of Research Proposals and Projects

The Safety Committee has reviewed and evaluated several research proposals, for example, "Assessment of SARS-CoV-2 Survival in Wastewater Treatment Facilities" and other innovative proposals and ideas submitted for the Chancellor's Award in its 6th Cycle 2020/2021.

The members of the Safety Committee participated in several safety related meetings, for example,

- FMDHS Meeting – Laboratory Safety Management, developing a comprehensive chemical inventory in UAEU and the centralized chemical procurement system.
- The 2nd USHER Meeting, March 16th, 2017 at UAEU: challenges facing a health and safety officer at the UAEU (budgetary needs and on cooperation of the university staff and students in regard to health and safety). Developed online systems in health and safety at NYU Abu Dhabi, e.g. on-line training system on health and safety, challenges faced (removal of hazardous wastes).

Safety Control for Lone Working on Campus

To prevent incident due to lone working; a line manager should approve a staff to work alone on the campus during the work from home policy implementation. The line manager provides a procedure for checking on the staff well-being, specify the minimum time intervals for regular checks and give instructions on what to do if the staff cannot be contacted. Immediate contact information has been provided in case of emergency.

Minuted Meetings of the College Safety Committee (Example)

The College Safety Committee met on December 15th, 2019 and discussed some Safety Issues in the College of Engineering. Among the minutes of the meeting are the following:

- The Committee members stressed their adherence of safety issues in running their departments' labs.
- The Committee members stressed that it is the responsibility of the staff/faculty member to be sure about the safety issues and protective measures before ordering any materials (by referring to the MSDS) and the COE Safety Manual.
- The Committee Chair briefed the members about a safety case related to an H_2S gas cylinder bought to one lab without considering safety measures (and the case immediately resolved)
- The Committee recommended that the number of students per practical/experimental lab should be in proportion to the size of that lab and the number of supervisors / instructors available during lab sessions. UAEU Khadamat should be consulted before increasing the ceiling of any lab section above the ceiling of that lab.
- The Committee recommended to hire additional instructors and technicians for the Departments' Labs who have large intake of students per year.
- The Committee recommended to the Dean to hire at least one multi-functional electro-mechanic specialist (engineer/technician) to help in fixing lab setups (teaching and research) in order to reduce/eliminate the risk of mechanical and electrical failures and prevent any possible leaks from such setups.

Lectures on Safety Considerations

The Committee members participated in offering lectures on Safety Considerations for both female and male students as part of the Graduation Projects requisite.

Prof. Samir Abu-Eishah,

Chair, COE Safety Committee

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EMERGENCY SITUATIONS

2. EMERGENCY SITUATION

2.1 Shared Laboratories

The responsible departments assign a faculty supervisor to each lab, who is responsible for enforcing the safety rules and preparing any lab material or equipment requirements for proper lab operation.

The original design of the Shared Laboratories' buildings was intended to house UAE University classrooms and instructional laboratories. Currently the buildings are occupied by multiple departments, some of which require research areas and/or the use of hazardous materials (various quantities of chemicals and gases).

A Fire Protection Consultants [Rolf Jensen & Associates (RJA) Inc.], had conducted a series of drawing reviews and on-site surveys to establish the fire protection features in the shared labs. The results of the reviews and the on-site surveys are documented in the "Fire Safety Survey Report", dated 25 November 2012. The report outlines the classification method of the laboratories and identifies their minimum fire protection features.

The fire protection features are based on types and quantities of hazardous materials within the labs. A database of materials has been established and maintained to ensure that the types and quantities of these hazardous materials are not exceeded. Additional fire protection features should be implemented if the types and quantities of hazardous materials are exceeded.

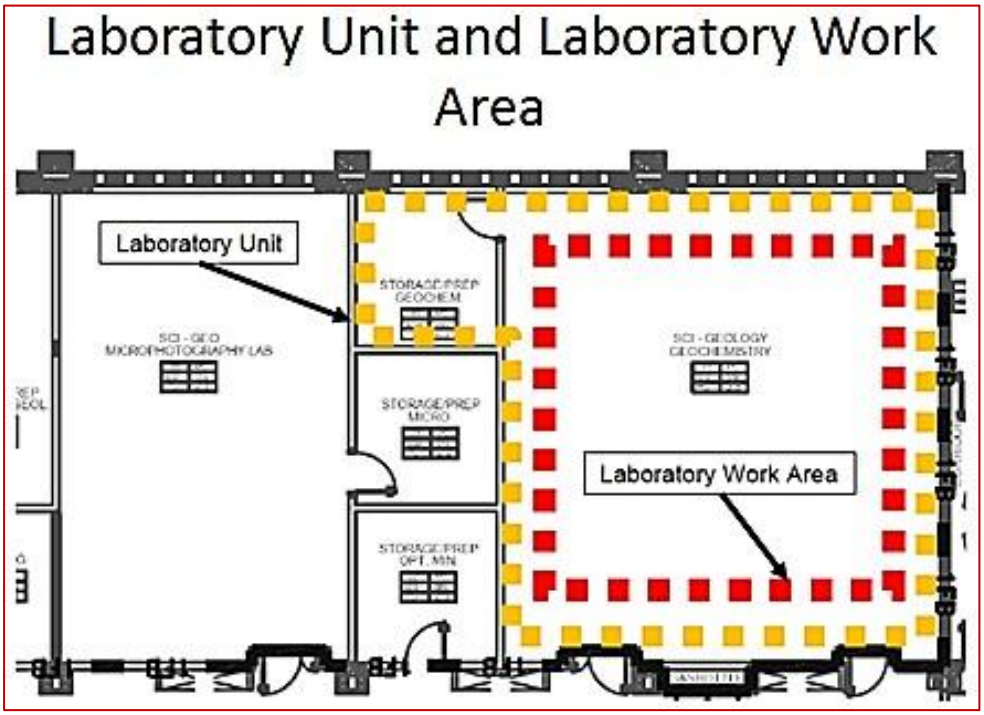
The maximum allowable quantities are established based on the various areas in the building. The areas are defined as shown in **Figure 2.1** as follows:

(1) **Laboratory work area (Red);** the room or space for testing, analysis, research, instruction, or similar activities that involve the use of chemicals.

(2) **Laboratory unit (Orange);** the enclosed space used for experiments or tests and may include offices, lavatories, and other contiguous rooms maintained for or used by laboratory personnel, and

(3) **Control area (Blue);** the series of laboratory units that are separated from other control areas by 1-hour fire-rated walls with 45-minute fire-rated doors.

The Engineering Labs classified by Department, Location (Shared Building-Room), Lab Name, User name, Contact Numbers (Mobile and Landline) are shown in **Table 2.1**.



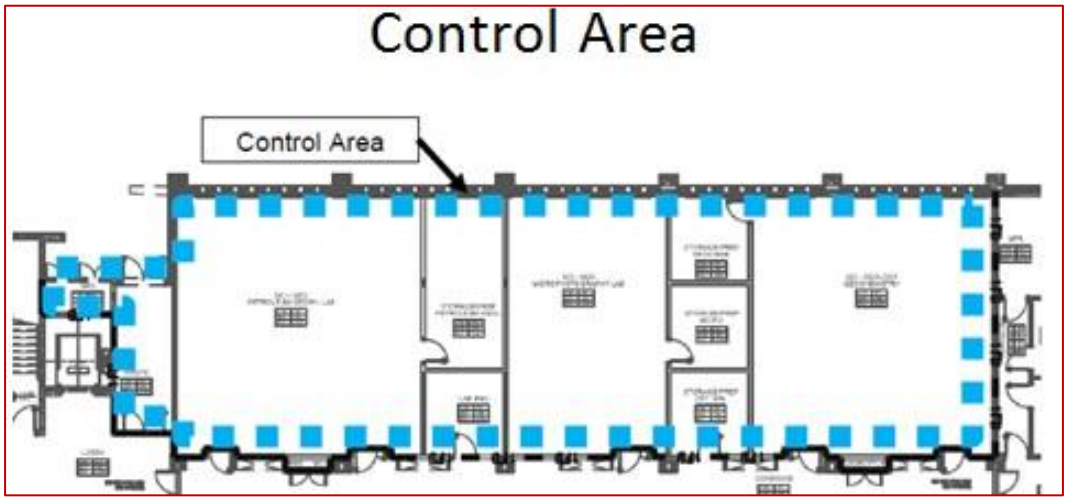


Figure 2.1 – Laboratory Areas: Laboratory Work Area (Red), Laboratory Unit (Orange), and Control Area (Blue)

Table 2.1: Engineering Labs classified by Department, Location (Shared Building-Room), Lab Name, User name, Contact Number (mobile) and Landline Number (office).

Note: If calling from outside the UAEU organization, dial (+971-3-713-xxxx) before the extension.

Dept.	Bldg.- Rm	Lab Name	User Name	Mobile 050-yyyy	Landline 713-xxxx
AE	E5-1014	Modeling Lab	Abdellatif Dosouki	-	x-5696
EE	E6-1007	EE Workshop (1)	Fadia Ali Ahmed	-7533120	x-6641
EE	E6-1010	Communications & Microprocessors Lab	Fadia Ali Ahmed	-7533120	x-6641
EE	E6-1011	Electrical Computing Lab	Hassan Gaafar	-7938896	x-6638
EE	E6-1008	Electrical Computing Lab	Hassan Gaafar	-7938896	x-6638
EE	E6-1013	Circuits and Electronics Lab	Adel Abd El Latif	-7136094	x-6643
EE	E6-1004	EE Workshop (2)	Adel Abd El Latif	-7136094	x-6643
EE	E6-0006	Electrical Machines Lab	Ahmed M. Abd-Rabou	-7132542	x-6635
EE	E6-0008	Control and Automation Lab	Ahmed M. Abd-Rabou	-7132542	x-6635
EE	E7-0003	Electrical Power Lab	Ahmed M. Abd-Rabou	-7132542	x-6635
EE	E7-0007	Research and Special Projects	Abdulrahman Dahir	-7301567	x-6254
EE	E7-0012	High Frequency Lab	Abdulrahman Dahir	-7301567	x-6254
ME	E6-2011	Mechanics of Materials Lab	Abdul Sattar Noureldin	-5630776	x-6441
ME	E6-2013	Heat Transfer and AC Lab	Abdul Sattar Noureldin	-5630776	x-6441
ME	E6-2015	Material Lab	Abdul Sattar Noureldin	-5630776	x-6441
ME	E6-2020	Control & Mechatronics Lab	Muthanna Ahmed Aziz	-3348020	x-6446
ME	E6-2016	Dynamics & Vibration Lab	Muthanna Ahmed Aziz	-3348020	x-6447
ME	E6-2014	CAD/CAM & Design Lab	Muthanna Ahmed Aziz	-3348020	x-6448
ME	E6-2008	Metrology Lab	Muthanna Ahmed Aziz	-3348020	x-6449
ME	E6-2006	Automotive Lab	Muthanna Ahmed Aziz	-3348020	x-6450
ME	E6-2007	Manufacturing Lab	Eng. Mohamed El-Said	-5833041	x-6491

ME	E6-2004	Energy Conversion & Renewable Lab	Eng. Mohamed El-Said	-5833041	x-6491
ME	E7-0014	Fluid Mechanics Lab	Eng. Mohamed El-Said	-5833041	x-6491
ME	E7-0016	Heat & Thermo. Lab	Rajesh Ganithi	-2778696	x-4502
ME	E7-0017	Mechanical Workshop	Moh'd Gias Uddin	-3278929	x-6439
ME	E7-0017	Mechanical Workshop	Abdulrahman Moh'd	-4932124	x-6438
ME	E6-2010	Bioengineering Lab	Research lab		
CEE	E7-0011	Structures Lab	Eng. Tarek Shaikhooun	-6194342	x-
CEE	E7-0010	Environmental Eng. Lab	Eng. Salem Hegazy	-6732428	x-
CEE	E7-0007	Concrete Lab	Eng. Ehab El-Said	-3382738	x-
CEE	E5-0005	Highway Mat. + Trans. Lab	Eng. Tarek Shaikhooun	-6194342	x-
CEE	E5-0005	Soil Mechanics Lab	Eng. Hanan Al Saedi	-3555280	x-
CEE	E5-0008	Surveying Lab	Eng. Hanan Al Saedi	-3555280	x-
CEE	E5-0010	Hydraulics & Water Lab	Eng. Salem Hegazy	-6732428	x-
PE	E6-0014	PVT Analysis lab	Eng. N. A.-S. Anvar	-7900468	x-6429
PE	E6-0009	Drilling Lab	Eng. N. A.-S. Anvar	-7900468	x-6429
PE	E6-0016	Core Analysis	Eng. Essa G. Lwisa	-7825357	x-6408
CHE	E6-0011	Instrumental analysis lab (1)	Dr. Hussain A. El-Sayed	-5738008	x-6409
CHE	E6-0013	Instrumental analysis lab (2)	Dr. Hussain A. El-Sayed	-5738008	x-6409
CHE	E6-1014	Petroleum Testing lab			x-6407
CHE	E6-1016	Petroleum Production lab			x-6407
CHE	E6-1018	Biochemical Treatment	Research Lab		No line
CHE	E6-1019	Reactor & Control	Research Lab		No line
CHE	E6-1021	Research lab	Research lab		No line
CHE	E7-0004	Unit Operations lab	Sami Abdullah	-7303045	x-6431

2.2 Emergency Numbers

The College Safety Committee reviewed the Rolf Jensen and Associates (RJA) Report about the Fire and Safety in the University Shared Laboratories in 2013. As a result, the Committee requested the following to be applied and implemented, whenever and wherever applicable, in these laboratories:

1. Laboratory Information: (Department, Shared Building Code and Room No., Laboratory Name / Person in Charge (Engineer or Lab Technician), and their Contact Numbers).
2. Material Safety Data Sheet (MSDS) for all materials in the laboratories and have the MSDS information clearly shown/posted on bottles, containers or in the location/area where these materials are in use.
3. The contact numbers of the technician(s) in charge of the lab are posted on all doors (inside and outside) of the laboratory as well as the emergency contact numbers (Khadamat Facilities Management / Security) to call within the University campus.
4. The faculty, technicians and students are aware (in case of emergency) to call Khadamat Facilities Management / Security at their emergency contact number(s).
5. Reevaluation of hazard level after adding new chemicals to any laboratory.
6. Restrict access to the laboratories to concerned people only, especially after 5 pm.
7. Add Electrical, Mechanical, Biological, and Radioactive hazard data sheets.

In addition, the Safety Committee is discussing with the University Facilities Management Department (FMD) in order to store chemicals and non-chemicals within the campus but outside the shared laboratories, store gas cylinders (with supply lines plus hazard protection system) and waste chemicals outside the shared laboratories' buildings.

Emergency Contact	Contact Number
Campus Security / Service Desk	03-713-8000
Campus Maintenance	03-713-8000
Gate Security	03-713-8060
Civil Defense / Fire Department	9-997
Ambulance	9-998
Police Station	9-999
Electric Emergency	8009008
Water Emergency	8009008

2.3 Reporting Accidents

All accidents, injuries, or near-misses should be reported to your instructor or lab engineer / technician who is required to submit a *Report of Accident, Injury, or Occupational Illness* and send it to the Chairman of the Department. Students and lab engineers should understand that the purpose of reporting and documenting accidents is not to affix blame, but instead to determine the cause of the accident so that similar incidents may be prevented in the future.

Minor injuries many times are not reported because they are perceived to be embarrassing or that "careless actions" lead to the accident. However, minor injuries can sometimes lead to more serious complications that only become evident at a later time. Taking corrective action as a result of a minor accident may keep a major incident from happening. Without knowledge of all minor accidents, the desirable investigation and resulting corrective actions are circumvented.

The format of the report as issued by Khadamat Facilities Management under (**MS.F.10.1 Incident Investigation Report**) covers the following items: Identifying Information, Description, Cause Analysis, Action Plan, Cause Checklist, and Reviewer Comments.

All shared laboratory buildings have posted information and instructions on each of the following, which are administered by Khadamat Facilities Management:

- Fire alarm control system following an alarm/supervisory/trouble conditions.
- Fire alarm and air conditioning system interface
- Gas alarm panels
- Actions in the case of emergency
- Emergency evacuation plans
- Monitoring Panels (FM-200)

In addition, all Shares Laboratory buildings have fire lines with fire hose reels and extinguishers; gas cylinder rooms, and hazardous waste rooms. Evacuation (Escape) Chairs are also available for handicap persons in all buildings.

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EMERGENCY PROCEDURES

3. EMERGENCY PROCEDURES

3.1 Introduction

During the course of normal laboratory operations there is always the potential for an emergency situation to arise. These emergencies can be the result of a fire, chemical exposure, chemical spill, or the need for medical assistance. In the event of an emergency, an emergency response plan should be implemented. This plan would include evacuation of the facility if deemed appropriate.

Internal communication is very important during any emergency situation. It is essential that all employees know how to act and react during the emergency. To accomplish this, it is necessary that a written Emergency Response Plan be developed and that all employees are trained on how to act accordingly. All accidents, regardless of severity, should be reported and investigated.

3.2 Fires

3.2.1Building Fires

The following steps are recommended if a fire occurs in a building:

1. Initiate a building evacuation using the nearest alarm pull station.
2. **Dial 9-997** to notify Civil Defense and request Fire Department assistance.
3. If the fire is small and you have been trained in the use of portable fire extinguishers, you may attempt to extinguish the fire. Fight the fire from a position where you can escape. A fire contained in a small vessel can usually be suffocated by covering the vessel with a lid.
4. If your clothing catches fire, drop to the floor and roll to smother the fire. If a co-worker's clothing catches fire, lower the person to the floor and roll him or her to smother the flames. Use a safety shower immediately thereafter.
5. Use the nearest safe exit route to exit the building. Close all doors on the way out to prevent the spread of smoke and fire.
6. After exiting, immediately proceed to a safe location at least 30 meters from the building.
7. Do not re-enter the building until the all clear is given by the fire department.

3.2.2 Laboratory Fires

Fires are a common emergency in any laboratory and specifically in a laboratory with flammable chemicals. In the event of a fire, do the following things:

1. Assist any person in immediate danger to safety, if it can be accomplished without risk to you.
2. Immediately activate the building fire alarm system.

3. If the fire is small enough and you have been trained in the use of portable fire extinguishers, you may attempt to extinguish the fire. Fight the fire from a position where you can escape. A fire contained in a small vessel can usually be suffocated by covering the vessel with a lid of some sort.
4. DON'T fight the fire if either of these conditions exist:
    a. The fire is too large or out of control.
    b. The atmosphere is toxic.
5. If the first attempts to put out the fire do not succeed, evacuate the building immediately.
6. Doors, and if possible, windows, should be closed as the last person leaves a room or area of a laboratory.
7. Don't use elevators; use building stairwells.
8. When they hear the fire alarm sound, all personnel in the affected areas shall evacuate the building immediately.
9. Upon evacuating the building, personnel shall proceed to a designated area at least 50 meters from the affected building.
10. No personnel are allowed to re-enter the building without permission.
11. You must report all fires to your supervisor.

3.2.3 Fire Safety Reminders

- Never use an elevator if the building fire alarm is activated.
- Use stairwells to evacuate the building. Be aware of your primary and secondary egress routes.
- Never block open corridor/hallway doors in a building.
- Check all appliances in your office before leaving. Turn them off.
- Keep storage in all areas 40 cm or more below sprinkler heads.
- Use electrical extension cords properly. Examine the cords periodically for safe service.

3.3 Chemical Exposures

The following procedures should be followed in the event of a chemical exposure. In all cases, the incident should be reported to your laboratory engineer, technician or principal investigator, regardless of severity.

3.3.1 Chemicals on Skin or Clothing

1. Immediately flush with water for no less than 15 minutes (except for hydrofluoric acid). For larger spills, the safety shower should be used.
2. While rinsing, quickly remove all contaminated clothing or jewelry.
3. Use caution when removing pullover shirts or sweaters to prevent contamination of the eyes.
4. Check the MSDS to determine if any delayed effects should be expected.

5. Discard contaminated clothing or launder them separately from other clothing. Leather garments or accessories cannot be decontaminated and should be discarded.

Do not use solvents to wash skin. They remove the natural protective oils from the skin and can cause irritation and inflammation. In some cases, washing with a solvent may facilitate absorption of a toxic chemical.

For flammable solids on skin, first brush off as much of the solid as possible, then proceed as described above.

For hydrofluoric acid, rinse with water for 5 minutes and apply calcium gluconate gel, then get immediate medical attention. If no gel is available, rinse for 15 minutes and go immediately to a health center.

3.3.2 Chemicals in Eyes

1. Immediately flush eye(s) with water for at least fifteen minutes. The eyes must be forcibly held open to wash, and the eyeballs must be rotated so all surface area is rinsed. The use of an eye wash fountain is desirable so hands are free to hold the eyes open. If eyewash is not available, pour water on the eye, rinsing from the nose outward to avoid contamination of the unaffected eye.
2. Remove contact lenses while rinsing. **Do not lose time removing contact lenses before rinsing.** Do not attempt to rinse and reinsert contact lenses.
3. Seek medical attention regardless of the severity or apparent lack of severity. Call **9-998** if an ambulance or transportation to a health center is needed. Explain carefully what chemicals were involved.

3.3.3 Chemical Inhalation

1. Close containers, open windows or otherwise increase ventilation, and move to fresh air.
2. If symptoms, such as headaches, nose or throat irritation, dizziness, or drowsiness persist, seek medical attention by calling **9-998** or going to a health center. Explain carefully what chemicals were involved.
3. Review the MSDS to determine what health effects are expected, including delayed effects.

3.3.4 Accidental Ingestion of Chemicals

1. Immediately go to the health center or call Ambulance at **9-998** for instructions.
2. ***Do not induce vomiting*** unless directed to do so by a health care provider.

3.3.5 Accidental Injection of Chemicals

Wash the area with soap and water and seek medical attention, if necessary immediately go to a health center or call Ambulance at **9-998.** Explain carefully what chemicals were involved.

3.4 Chemical Spills

All chemical spills, regardless of size, shall be reported in writing to your supervisor. The report shall include the date, time, location, chemical(s) and their volume, and names of all persons involved, including any visitors who were exposed and personnel involved in the clean-up.

3.4.1 Emergency Spills

A chemical spill is classified as an Emergency Spill whenever it:

1. Causes personal injury or chemical exposure that requires medical attention;
2. Causes a fire hazard or uncontrollable volatility;
3. Requires a need for breathing apparatus of the supplied air or self-contained type to handle the material involved;
4. Involves or contaminates a public area;
5. Causes airborne contamination that requires local or building evacuation;
6. Causes a spill that cannot be controlled or isolated by laboratory personnel;
7. Causes damage to University property that will require repair;
8. Involves any quantity of metallic mercury;
9. Cannot be properly handled due to lack of local trained personnel and/or equipment to perform a safe, effective cleanup;
10. Requires prolonged or overnight cleanup; or
11. Involves an unknown substance.

The following tactics are prioritized in terms of usual preferred action sequences. However, each spill incident is unique and involves persons with varying levels of spill expertise and experience. Thus, for any individual incident, isolation of the spill and/or securing the area might best occur prior to or simultaneously with calling Police at **9-999**

1. Call the Campus Security for assistance at (**03-713-8000**) and notify the dispatcher of location of the spill and, if known, the chemical being spilled.
2. If the spill presents an immediate danger, leave the spill site and warn others, control entry to the spill site.
3. Remove contaminated clothing. Flush skin/eyes with water at least 15 minutes to 30; use soap for intermediate and final cleaning of skin areas.
4. Protect yourself, and then remove injured person(s) to fresh air, if safe to do so.
5. Notify nearby persons and evacuate as necessary. Prevent entry, as necessary, by posting a guard in a safe area and/or shutting doors.
6. If flammable vapors are involved, do not operate electrical switches unless to turn off motorized equipment. Try to turn off or remove heat sources, where safe to do so.
7. If the substance involved is an unknown, then emergency spill response procedures are limited to self-protection, notification of Campus Security at **03-713-8000** for response, isolation of the chemical, and evacuating and securing the area involved.

8. Do not touch the spill without protective clothing.
9. Where the spill does not present immediate personal danger, try to control the spread or volume of the spill. This could mean shutting a door, moving nearby equipment to prevent further contamination, repositioning an overturned container or one that has a hole in the bottom or side, creating a dike by putting an absorbent around a spill or opening the sashes on the fume hoods to facilitate removal of vapors.
10. Never assume gases or vapors do not exist or are harmless because of lack of smell.
11. Increase ventilation by opening closed fume hood sashes to the 12 inch or fully open position. Exterior doors may be opened to ventilate non-toxic vapors.
12. Use absorbents to collect substances. Reduce vapor concentrations by covering the surface of a liquid spill with absorbent. Control enlargement of the spill area by confining with absorbent.

3.4.2 Minor Spills

Minor spills are those spills that do not fit the requirements for Emergency Spills. The following general procedures should be used for all minor spills:

1. Attend to any persons who may have been contaminated. If these persons require medical attention this is an Emergency Spill (see above).
2. Notify persons in the immediate area about the spill.
3. Evacuate all nonessential personnel from the spill area.
4. If the spilled material is flammable, turn off ignition and heat sources.
5. Avoid breathing vapors of the spilled material. If respiratory protection is necessary this is an Emergency Spill (see above).
6. Leave on or establish exhaust ventilation if it is safe to do so.
7. Secure supplies to effect cleanup.
8. Put on appropriate personnel protective equipment.
9. Spilled Liquids
    a. Confine or contain the spill to a small area. Do not let it spread.
    b. For small quantities of inorganic acids or bases, use a neutralizing agent or an absorbent mixture (e.g., soda ash or diatomaceous earth). For small quantities of other materials, absorb the spill with a noncreative material (such as vermiculite, clay, dry sand, or towels).
    c. For larger amounts of inorganic acids and bases, flush with large amounts of water (providing the water will not cause additional damage). *Flooding is not recommended in storerooms where violent spattering may cause additional hazards or in areas where water-reactive chemicals may be present.*
    d. Mop up the spill, wringing out the mop in a sink.

e. Carefully pick up and clean any cartons or bottles that have been splashed or immersed.

f. If the spilled material is extremely volatile, let it evaporate and be exhausted by the laboratory hood (provided that the hood is authorized for use with the spilled chemical).

10. Spilled Solids

a) Generally, sweep spilled solids into a dustpan and place them into a container suitable for that chemical.

b) Dispose of residues according to safe disposal procedures. Remembering that personal protective equipment, brooms, dustpans, and other items may require special disposal procedures.

c) Report the chemical spill in writing as required above.

3.4.3 Mercury Handling and Spill Clean-Up

3.4.3.1 Storage and Handling

- Always store mercury in unbreakable containers and stored in a well-ventilated area.
- When breakage of instruments or apparatus containing mercury is a possibility, the equipment should be placed in an enameled or plastic tray or pan that can be cleaned easily and is large enough to contain the mercury.
- Transfers of mercury from one container to another should be carried out in a hood, over a tray or pan to confine any spills.
- If at all possible, the use of mercury thermometers should be avoided. If a mercury thermometer is required, many are now available with a Teflon coating that will prevent shattering.
- Always wash hands after handling mercury.

3.4.3.2 Protective Clothing

For small spills, a laboratory coat, safety glasses, and gloves should be used. Gloves made of the following have been rated as excellent for protection against elemental mercury:

- Chlorinated polyethylene (CPE)
- Polyvinyl Chloride (PVC)
- Polyurethane
- Nitrile Rubber (also known by several brand names)
- Viton ®
- Butyl Rubber
- Neoprene

If mercury has been spilled on the floor, the workers involved in cleanup and decontamination should wear plastic shoe covers. Laboratory Engineer or Technician should be called immediately

if a spill is extensive enough to require workers to kneel or sit where mercury has been spilled since impermeable clothing will be required.

3.4.3.3 Spill Kits

Special spill kits are available from a variety of sources. If a spill kit is purchased, follow the manufacturer's directions. Alternatively, a kit can be assembled with the following components:

1. Protective gloves,
2. Mercury suction pump or disposable pipettes to recover small droplets,
3. Elemental zinc powder,
4. Dilute sulfuric acid (5-10%) in spray bottle,
5. Sponge,
6. Plastic trash bag,
7. Plastic container, and
8. Plastic sealed vial for recovered mercury.

3.4.3.4 Clean-Up Procedures

- Wearing protective clothing, pools and droplets of metallic mercury can be pushed together and then collected by a suction pump.
- After the gross contamination has been removed, sprinkler the entire area with zinc powder. Spray the zinc with the dilute sulfuric acid.
- Using the sponge, work the zinc powder/sulfuric acid into a paste consistency while scrubbing the contaminated surface and cracks or crevices.
- After the paste has dried, it can be swept up and placed into the plastic container for disposal.
- Rags, shoe covers, sponges, and anything used for the cleanup should be placed in the trash bag to be disposed of as contaminated material.

3.5 Medical Emergencies

Personal injury is not uncommon in laboratories. These injuries are usually minor cuts or burns but can be as severe as acute effects of chemical exposure or incidents such as heart attacks or strokes. Prevention of injuries should be a major emphasis of any laboratory safety program. Proper training will help prevent injuries from glassware, toxic chemicals, burns and electrical shock.

In the event of any personal injury, the initial responsibility for first aid rests with the first person(s) at the scene, who should react quickly but in a calm and reassuring manner. The person assuming responsibility should:

1. Immediately call **9-998** for medical help and medical emergencies.

2. Be explicit in reporting suspected types of injury or illness, location of victim, and type of assistance required.
3. Send someone to meet the ambulance crew at likely entrances of the building.
4. Not move the injured person except where necessary to prevent further injury.

The phone numbers of the following should be posted in each laboratory:

- ➢ The name(s) of person(s) in the area trained in CPR and First Aid.
- ➢ The number to call for medical emergencies

3.6. General First Aid

1. First aid equipment should be readily available in each laboratory. See Section, 4.6.4 of this manual for additional information.
2. Following any first aid, a nurse or physician qualified to handle chemical emergencies should provide further examination and treatment. The location and phone number of emergency services should be clearly posted.
3. It is recommended that each Department have at least one person trained in basic first aid and cardiopulmonary resuscitation (CPR).
4. Someone knowledgeable about the accident should always accompany the injured person to the medical facility and a copy of any appropriate MSDS(s) shall accompany the victim if the accident resulted from chemical exposure.
5. Minor injuries requiring first aid should always be reported to a supervisor and recorded Reasons for this are as follows.
    a. A minor injury may indicate a hazardous situation that should be corrected to prevent a serious future injury.
    b. It is important to document a minor injury as having been “work related” if the injury later leads to serious complications, such as from an infected cut.

3.7 Personal Protection during First Aid

1. Persons responding to a medical emergency should be protected from exposure to blood and other potentially infectious materials. Protection can be achieved through adherence to work practices designed to minimize or eliminate exposure and through the use of personal protective equipment (i.e., gloves, masks, and protective clothing), which provide a barrier between the worker and the exposure source. For most situations in which first aid is given, the following guidelines should be adequate.
    a) For bleeding control with minimal bleeding and for handling and cleaning instruments with microbial contamination, disposable gloves alone should be sufficient.
    b) For bleeding control with excessive blood, disposable gloves, a coat, a mask, and protective eyewear are recommended.
    c) For measuring temperature or measuring blood pressure, no protection is required.

2. After emergency care has been administered, hands and other skin surfaces should be washed immediately and thoroughly with warm water and soap if contaminated with blood, other body fluids to which universal precautions apply, or potentially contaminated articles. Hands should always be washed after gloves are removed, even if the gloves appear to be intact.

3.8 Leaking Compressed Gas Cylinders

Occasionally, a cylinder or one of its component parts develops a leak. Most such leaks occur at the top of the cylinder in areas such as the valve threads, safety device, valve stem, and valve outlet.

If a leak is suspected, do not use a flame for detection; rather, a flammable-gas leak detector or soapy water or other suitable "snoop" solution should be used. If the leak cannot be remedied by tightening a valve gland or a packing nut, emergency action procedures should be affected. Laboratory workers should never attempt to repair a leak at the valve threads or safety device; rather, they should consult with the supplier for instructions.

4

SAFETY RULES

4. SAFETY RULES

4.1 General Safety Policies

(1) The safety and well-being of its students, faculty, and staff come above all other considerations at UAE University.

(2) No experiment that might subject personnel to unreasonable risk is acceptable, no matter how desirable the information, which might be obtained.

(3) It is the first duty of research directors, instructors, supervisors, Lab engineers and technicians, and all persons in authority, to provide for safety in the environment and operations under their control.

(4) It is the College of Engineering policy to comply not only with legal safety standards, but to act positively, where it can, to prevent injury, ill-health, damage and loss arising from work carried out within its buildings.

(5) The College of Engineering seeks to encourage all its members to participate in and contribute to the establishment and observance of safe working practices.

4.2 Elementary Safety Rules

1) Keep this manual within easy access in your laboratory and be familiar with its contents.

2) The safe way is the right way to do your job.

3) Plan your work.

4) Follow instructions.

5) Report every accident, spill, leak, or fire at once, no matter how trivial it is, to the Campus Security, **03-713-8000**.

6) If you do not know how to do the job, ask your instructor or research director. Report to the Safety Coordinator all unsafe conditions, unsafe acts and "near misses" which might cause future accidents.

7) Be able to use all safety devices and protective equipment provided for your use.

8) Know the location and contents of the nearest safety station. Maintain good housekeeping by keeping your work area clean and orderly.

9) Storage unused equipment in the storage room.

10) Wear proper clothing.

11) Avoid bringing long hair, loose sleeves, cuffs, rings, bracelets, etc. in proximity to moving machinery.

12) Proper shoes are required in the laboratory.

13) Horseplay in any form is dangerous and prohibited.

14) Do not run in laboratory areas or halls.

15) Do not oil, grease, or work on unprotected machinery in motion.

16) All machinery and equipment under repair and adjustment shall be properly "locked out" and tagged.

17) Know the evacuation procedure for your area, the location of fire exits, the location and use of fire extinguishers, and the proper method of reporting fires.

18) Compressed gas cylinders should be secured firmly.

19) Never move a cylinder unless the protective cap is screwed over the valve.

20) DON'T try completely new and untried experiments involving potentially dangerous chemicals without help.

21) Changes to common procedures, including: "scaling-up" a reaction; a change in heat source or reaction temperature or pressure; change in solvent; etc., turn a known procedure into a high-risk procedure.

22) Be sure to discuss all changes to known procedures with class instructor or lab engineer.

23) It is your responsibility to see that adequate information is supplied to protect safety personnel or firemen who may have to deal with an emergency situation in your laboratory.

24) Never leave a reaction or experiment running unattended.

25) NEVER carry out hazardous work alone, especially at night or over the weekends. Make sure someone is in visible or audible range to help you if something goes wrong.

26) Regardless of the work function, there should be a check procedure established at some regular interval to determine the physical state of the person working alone.

27) Keep aware of where your neighbors are.

28) Report every accident or fire, no matter how trivial, at once to the Campus Security, **03-713-8000**.

29) Smoking is prohibited in the whole building

4.3 General Safety Rules

4.3.1 Personal Safety Practices

Lab coats and safety glasses are required in laboratories employing chemicals, biohazards, or radioisotopes. Never wear shorts, sandals, or open-toed shoes in a lab.

- Do not allow children or pets in laboratories.
- Never pipette anything by mouth.
- Be aware of dangling jewelry, loose clothing, or long hair that might get caught in equipment.

- Store food and drinks in refrigerators that are designated for that use only.
- Never work alone in a lab if it is avoidable. If you must work alone, make someone aware of your location and have them call or check on you periodically.
- Wash your hands frequently throughout the day and before leaving the lab.
- Do not wear lab coats, gloves, or other personal protective clothing out of the lab and into non-lab areas. This clothing may have become contaminated and you could spread the contamination.
- Contact lenses should not be worn in a lab because chemicals or particulates can get caught behind them and cause severe damage to the eye.

4.3.2 Record Keeping

- It is the Lab Engineer/Technician responsibility to keep an updated hazardous chemical inventory poster on file and to post a current inventory summary sign on each lab storage cabinet. Lab personnel should also keep usage records of high-risk substances (Hazardous Chemical Inventory Instruction Sheet).
- Each Lab Engineer/Technician must document and report any lab accident that results in an injury to the Chairman of the Department. A student injured in a laboratory should complete a First Report of Injury or Illness (with the assistance of his or her Lab Engineer/Technician).
- Laboratory health and safety training records are maintained in the department. Any laboratory health and safety training conducted by department or college must be documented and must contain the following information: date, training outline, length of training, persons conducting the training, and employee's printed name and signature.
- An Organic Waste Log should be maintained in the laboratory and should be used to record the amount and type of organic waste.
- A Sewer Discharge Log should be maintained on a semester basis, reflecting the discharges over the preceding semester.
- Understand the chemical hazards and precautions specified in the pertinent MSDSs: See for example, MSDSs.
- MSDSs must be maintained for hazardous products in use. Departments are encouraged to maintain accessible copies of MSDSs. For immediate reference by any concerned worker

4.3.3 Housekeeping

The following recommendations are designed for accident prevention:

- Each laboratory engineer shall be responsible for maintaining the cleanliness of his/her area.
- Clean your work area throughout the day and before you leave the lab.
- If necessary, clean equipment after use to avoid the possibility of contaminating the next person who needs to use it.

- Equipment must be maintained in safe operating condition, including electrical wires in good condition and not overloaded to any one outlet, pumps, mercury bubblers vented to fume hoods, belt guards on pumps, all equipment electrically grounded, and refrigerators properly designated and used (food or chemicals/flammables, but not both);
- Reasonably neat and clean counter tops and shelves;
- Maintenance: Malfunctioning safety equipment detected by laboratory personnel during attempted use or visual surveys and used fire extinguishers should be reported immediately to the Chairman of the Department to coordinate prompt repair or replacement.
- Keep all aisles and walkways in the lab clear to provide a safe walking surface and an unobstructed exit.
- Do not block access to emergency equipment and utility controls.

4.3.4 Labeling and Signs

- Prominent signs and labels of the following types should be used:
- Location signs shall be prominently posted to indicate safety showers, eyewash stations, and other safety and first aid equipment
- Warning signs at areas or equipment where special or unusual hazards exist;
- The manufacturer's label should be kept intact. Do not intentionally deface or obscure the label or the hazard warnings.
- When a chemical is transferred from the original container into a secondary container for storage, the new container should be labeled with the name of the product, the chemical constituents and the primary hazard warnings;
- A plan showing evacuation route(s) should be posted prominently in each laboratory;
- Telephone numbers to be called in case of fire, accident, hazardous chemical spill, or emergency.

4.3.5 Storage

Major chemical hazard classes should physically segregate chemicals. Incompatibles within these classes should also be segregated. **Table 4.1** lists segregation categories of chemicals usage.

Table 4.1. Segregation categories of chemicals usage

Acids	➢ Segregate acids from active metals such as sodium, potassium, magnesium, etc. ➢ Segregate oxidizing acids from organic acids such as glacial acetic acid and from flammable and combustible materials, such as cardboard boxes.

	➢ Segregate acids from chemicals which could generate toxic or flammable gases upon contact, such as sodium cyanide, iron sulfide, calcium carbide, etc. ➢ Segregate acids from bases.
Bases	➢ Segregate bases from acids, metals, explosives, organic peroxides and easily ignitable materials.
Flammables	➢ Store in approved safety cans or cabinets. Segregate from oxidizing acids and oxidizers. Keep away from any source of ignition: heat, sparks, or open flames.
Oxidizers	➢ Store in a cool dry place. Keep away from combustible and flammable materials. Keep away from reducing agents such as zinc, alkali metals, and formic acid.
Cyanides	➢ Segregate from acids and oxidizers.
Water Reactive Chemicals	➢ Store in a cool dry place away from any water source. Have a Class D fire extinguisher available in case of fire.
Pyrophoric Substances	➢ (Materials that will react with the air to ignite when exposed, e.g., white phosphorus.) Store in a cool dry place, making provisions for an airtight seal.
Light Sensitive Chemicals	➢ Store in amber bottles in a cool, dry, dark place.
Peroxidizable Chemicals	➢ Store in airtight containers in a dark and cool place. Most peroxidizable compounds are flammable and should be stored in a flammable liquid storage cabinet or room. Label containers with receiving, and opening dates. Periodically test for the presence of peroxides. Discard before exceeding expiration date.
Toxic Chemicals	➢ Store according to the nature of the chemical, using appropriate security where necessary.
Nitrated Compounds	➢ Nitrated compounds can be considered explosive; special care and handling should be exercised.

Source: UW Laboratory Safety Manual: http://www.ehs.washington.edu/manuals/lsm/lsm.pdf

4.3.6 General considerations

The following are the general storing rules for storing materials and equipment in cabinets and on shelves:

- Do not store flammable liquids in a refrigerator unless it is approved for such storage. Such refrigerators are designed with non-sparking components to avoid an explosion.
- Storing materials and equipment on top of cabinets should be avoided.
- Make sure that the weight of the chemicals does not exceed the load capacity of the shelf or cabinet.
- Heavy-duty brackets and standards should be used for wall-mounted shelving must have.
- Cabinets for chemical storage must be of solid, sturdy construction, preferably hardwood or metal.

- Do not store materials on top of high cabinets where they will be hard to see or reach.
- Do not store corrosive liquids above eye level.
- Return the chemicals to their proper locations after each use.
- Store chemicals that do not require a ventilated cabinet inside a closable cabinet.
- Do not expose chemicals to heat or direct sunlight.
- Do not storage of incompatible chemicals in one cabinet.
- If a primary container breaks or leaks, material should be collected and stored in corrosion resistant storage trays or secondary containers by a person trained to handle that chemical safely.

4.3.7 Storage of flammable liquid (Fire Hazard)

A maximum of 10 gallons of flammable liquids, in approved containers, may be stored outside of a flammable liquid cabinet. See **Table 4.2** for approved flammable liquid storage containers types and limits.

Table 4.2. Approved Storage Containers for Flammable and Combustible Liquids (FP = Flash Point; BP = Boiling Point). $^{o}C = (^{o}F-32)/1.8$

	Flammable Liquids			**Combustible Liquids**	
Container Type	**Class IA** FP < 73 °F BP < 100 °F (Ethyl ether)	**Class IB** FP < 73 °F BP ≥100 °F (Hexane)	**Class IC** 73°F< FP ≤ 100 °F (Diesel fuel)	**Class II** 100°F< FP < 140 °F (Mineral spirits)	**Class III** FP ≥ 140 °F (Kerosene)
Glass	1 pint *	1 quart *	1 gallon	1 gallon	5 gallons
Metal	1 gallon	5 gallons	5 gallons	5 gallons	5 gallons
Approved plastic	0	0	0	0	5 gallons
Safety can	2 gallons	5 gallons	5 gallons	5 gallons	5 gallons

* Containers may be up to 1 gallon for reagents of Analytical Purity Grade or High Grade.

** Source: UW Laboratory Safety Manual,http://www.ehs.washington.edu/manuals/lsm/lsm.pdf.

4.3.8 Chemical Incompatibility Chart

Mixing these chemicals purposely or as a result of a spill can result in heat, fire, explosion, and/or toxic gases. **Table 4.3** gives a partial list of these chemicals.

Table 4.3. A partial list of incompatible chemicals

Chemical	**Keep the chemical out of contact with**

Acetic Acid	Chromic acid, nitric acid, hydroxyl-containing compounds, ethylene glycol, perchloric acid, peroxides, and permanganates.
Acetone	Bromine, chlorine, nitric acid, sulfuric acid, and hydrogen peroxide.
Acetylene	Bromine, chlorine, copper, mercury, fluorine, iodine, and silver.
Alkaline and Alkaline Earth Metals such as calcium, lithium, magnesium, sodium, potassium, powdered aluminum	Carbon dioxide, carbon tetrachloride and other chlorinated hydrocarbons, water, Bromine, chlorine, fluorine, and iodine. **Do not** use CO_2, water or dry chemical extinguishers. Use Class D extinguisher (e.g., Met-L-X) or dry sand.
Aluminum and its Alloys (especially powders)	Acid or alkaline solutions, ammonium persulfate and water, chlorates, chlorinated compounds, nitrates, and organic compounds in nitrate/nitrate salt baths.
Ammonia (anhydrous)	Bromine, chlorine, calcium hypochlorite, hydrofluoric acid, iodine, mercury, and silver.
Ammonium Nitrate	Acids, metal powders, flammable liquids, chlorates, nitrates, sulfur and finely divided organics or other combustibles.
Aniline	Hydrogen peroxide or nitric acid.
Bromine	Acetone, acetylene, ammonia, benzene, butadiene, butane and other petroleum gases, hydrogen, finely divided metals, sodium carbide, and turpentine.
Calcium Oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents.
Caustic (soda)	Acids (organic and inorganic).
Chlorates or Perchlorates	Acids, aluminum, ammonium salts, cyanides, phosphorous, metal powders, oxidizable organics or other combustibles, sugar, sulfides, and sulfur.
Chlorine	Acetone, acetylene, ammonia, benzene, butadiene, butane and other petroleum gases, hydrogen, finely divided metals, sodium carbide, turpentine.
Chlorine Dioxide	Ammonia, methane, phosphine, hydrogen sulfide.
Chromic Acid	Acetic acid, naphthalene, camphor, alcohol, glycerin, turpentine and other flammable liquids.
Copper	Acetylene, hydrogen peroxide.
Cumene Hydro-peroxide	Acids
Cyanides	Acids
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, bromine, chlorine, fluorine, iodine.
Fluorine	Isolate from everything.

Hydrazine	Hydrogen peroxide, nitric acid, and other oxidizing agents.
Hydrocarbons	Bromine, chlorine, chromic acid, fluorine, hydrogen peroxide, and sodium peroxide.
Hydrocyanic Acid	Nitric acid, alkali.
Hydrofluoric Acid	Ammonia, aqueous or anhydrous.
Hydrogen Peroxide (anhydrous)	Chromium, copper, iron, most metals or their salts, aniline, any flammable liquids, combustible materials, nitro-methane, and all other organic material.
Hydrogen Sulfide	Fuming nitric acid, oxidizing gases.
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen.
Mercury	Acetylene, alkali metals, ammonia, fulminic acid, nitric acid with ethanol, hydrogen, oxalic acid.
Nitrates	Combustible materials, esters, phosphorous, sodium acetate, stannous chloride, water, zinc powder.
Nitric acid (concentrated)	Acetic acid, acetone, alcohol, aniline, chromic acid, flammable gases and liquids, hydrocyanic acid, hydrogen sulfide and nitratable substances.
Nitrites	Potassium or sodium cyanide.
Nitro-paraffins	Inorganic bases, amines.
Oxalic acid	Silver, mercury, and their salts.
Oxygen (liquid or enriched air)	Flammable gases, liquids, or solids such as acetone, acetylene, grease, hydrogen, oils, phosphorous.
Perchloric Acid	Acetic anhydride, alcohols, bismuth and its alloys, paper, wood, grease, oils or any organic materials and reducing agents.
Peroxides (organic)	Acid (inorganic or organic). Also avoid friction and store cold.
Phosphorus (white)	Air, oxygen.
Phosphorus pentoxide	Alcohols, strong bases, water.
Potassium	Air (moisture and/or oxygen) or water, carbon tetrachloride, carbon dioxide.
Potassium Chlorate	Sulfuric and other acids.
Potassium Perchlorate	Acids.
Potassium Permanganate	Benzaldehyde, ethylene glycol, glycerol, sulfuric acid.
Silver and silver salts	Acetylene, oxalic acid, tartaric acid, fulminic acid, ammonium compounds.
Sodium	See Alkali Metals

Sodium Chlorate	Acids, ammonium salts, oxidizable materials and sulfur.
Sodium Nitrite	Ammonia compounds, ammonium nitrate, or other ammonium salts.
Sodium Peroxide	Any oxidizable substances, such as ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfural, etc.
Sulfides	Acids.
Sulfur	Any oxidizing materials.
Sulfuric Acid	Chlorates, perchlorates, permanganates, compounds with light metals such as sodium, lithium, and potassium.
Water	Acetyl chloride, alkaline and alkaline earth metals, their hydrides and oxides, barium peroxide, carbides, chromic acid, phosphorous oxychloride, phosphorous pentachloride, phosphorous pentoxide, sulfuric acid, sulfur trioxide.

4.3.9 Compressed gas cylinder storage

Cylinders containing the compressed gases listed below must be stored in a ventilated enclosure (cage) outside the labs. Cylinders must be positioned and secured at all times so that they will not fall down. A list of the compressed gases expected to be stored is given in **Table 4.4**.

Table 4.4. A list of compressed gases expected to be stored

Acetylene Ammonia Arsenic Pentafluoride Arsine Boron Trifluoride 1,3 – Butadiene Carbon Monoxide Carbon Oxysulfide Chlorine Chlorine monoxide, ClO Chlorine trifluoride, ClF_3 Chloroethane Cyanogen Diborane	Dichloroborane Dichlorosilane Dimethyl amine Ethane Ethylamine Ethylene Ethylene oxide Fluorine Formaldehyde Germane Hydrogen Chloride, anhydrous Hydrogen Cyanide Hydrogen Fluoride	Hydrogen Selenide Hydrogen Sulfide Methylamine Methyl Bromide Methyl Chloride Methyl mercaptan Nitrogen oxides Phosgene Phosphine Silane Silicon tetrafluoride Stibine Trimethyl amine Vinyl Chloride

4.3.10 Unattended Operation

- Unattended operations or experiments should be avoided whenever possible.
- It is the responsibility of the worker to design all experiments so as to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas.
- If an operation needs to run longer than working hours, the door to the room must be labeled with the name and phone number where the person responsible for the reaction can be reached.
- Clear directions for an untrained person to shut down the operation during an emergency should be posted.
- Arrangements should be made for other workers to periodically inspect the operation.
- Laboratory lights should be left on, and signs should be posted identifying the nature of the experiment and the hazardous substances in use.

4.3.11 Working Alone

Working alone in the labs is not allowed under any conditions if hazards exist. An individual is advised to work only under conditions in which appropriate emergency aid is available when needed.

4.3.12 Handling and Transporting Chemicals

To avoid spills and chemical exposure due to incorrect transportation of chemicals consider the following:

- Keep chemicals in their original packing when transporting, if possible.

- When transporting compressed gas cylinders, do not carry or roll the cylinders from one area to another. The cylinder should always be strapped in a cylinder cart and the valve protected with a cover cap.
- Use a bottle carrier, cart or other secondary container when transporting chemicals in breakable containers (especially 250 ml or more) through hallways or between buildings. Secondary containers are made of rubber, metal or plastic, with carrying handle(s).

4.3.13 Glassware Handling

- Only glass in good condition should be used and discard or send for repair all broken, chipped, starred or badly scratched glassware.
- Do not store glassware near the edge of shelves. Store large or heavier glassware on lower shelves.
- Avoid catching the glassware if it is dropped or knocked over.
- A proper size of the glassware should be used; allow at least 20% free space.

4.4. Safety Guidelines for Non-Regular Classes

- Students should be assigned to work in laboratories in which graduate students and/or postdoctoral associates are also working.
- Students should receive instruction and close supervision directly from their faculty mentor, although a senior graduate student or postdoctoral associate working with the faculty member may also be involved.
- Students should not work alone, particularly at night or on weekends, on operations involving chemicals or other hazards of the type covered in the Safety Manual. If work at night or on weekends is required, it should only be done with the express permission of the faculty mentor and with specific arrangements to avoid working alone.
- An outline of the independent study project, including the goal(s) and as far as practical, the kinds of experiments to be carried out, methods to be used and data to be collected, as well as a proposed schedule of accomplishments, should be completed (by the student and faculty member together) before the beginning of the first semester or as soon as possible thereafter. This will serve as a guide so that it is clear to student and mentor what each expects at each stage of the project and for the overall project. It would be appropriate for each to sign and keep a copy. This document should also state where the lab space for the project is and who else is to be involved in the supervision (if anyone).
- Supervising faculty and, if appropriate, associate supervisors, should discuss with the student the potential hazards of all experiments to be carried out, and closely supervise preparations for all new potentially hazardous operations.
- Students should agree with their supervising professors on a weekly work schedule and should make every effort to maintain this schedule.
- Students must read the concerned part(s) in the Safety Manual as specified by the instructor and sign a statement that they have done so, before they are allowed to begin laboratory work.

- In order to comply with first four guidelines above, those faculty without graduate students or postdoctoral associates or without lab space should enter into collaborations with other faculty who have students and facilities, or at least make necessary arrangements to "borrow" appropriate lab space. If at all possible, these arrangements should be made (at least tentatively) before students are accepted for supervision. If necessary, the Coordinator of Independent Study can be called on to facilitate arrangements.

4.5. Personal Protection

The laboratory should be kept clean and free from clutter, by regular maintenance. At the completion of each experiment, equipment should be cleaned and properly stored. Do not let unused equipment or chemicals accumulate in the lab. Do not use the aisles of the lab or the space in front of the emergency escape panels for storage. Dispose of all hazardous wastes in accord with the procedures indicated in this manual. Reagent bottles must be properly labeled – when pouring hold the bottle with its label to your palm to protect the label. Notify your safety officer of bottles whose contents are in doubt.

4.5.1 Hygiene

- Wash hands often–always before eating, smoking, or leaving the laboratory. Washing should be an instinctive reaction to spillage of any chemical on the skin.
- Never eat or drink in the lab – never use lab equipment as a food or drink container.
- No food items should ever be stored or even cooled in a laboratory refrigerator. Food and beverages can become contaminated within a very short period of time to a life-threatening level by absorption of chemical vapors. Any food/beverage found in inappropriate areas will be removed without notice.

4.5.2 Eye Protection

In all laboratories where chemicals are used there is the hazard of splashes or dust particles entering the eyes. Pressurized or vacuum vessels may explode or implode sending shrapnel through the lab. While working with electrical wiring there are hazards from molten solder and debris. When testing samples on Instrons or other equipment, pieces can chip and enter the eye. All of these activities, and many others, require the use of various types of eye protection listed in order of increasing effectiveness include:

1. Ordinary spectacles
2. Safety glasses with side shields
3. Protective goggles, which can be worn over spectacles, if necessary
4. Face shields
5. Head shields, which protect all of the head and throat

Most lab operations simply require the use of safety glasses. However, when any chemicals are being used at least chemical goggles should be used or in some cases a face shield is required.

4.5.3 Ear Protection

The healthy ear can detect sounds ranging from 15 to 20,000 hertz. Temporary exposure to high noise levels will produce a temporary hearing loss. Long-term exposure to high noise levels produces permanent hearing loss. There appears to be no hearing hazard (although possible psychological effects) to noise exposure below 80 dB. Exposure above 130 dB is hazardous and should be avoided. Earmuffs offer the highest noise attenuation, and are preferred for levels above 95 dB. Earplugs are more comfortable and are preferred in the 80-95 dB range. If you suspect that a hearing hazard exists then notify the instructor or lab engineer/technician to have the sound level measured.

4.5.4 Foot Protection

All persons in labs or on fieldwork must wear proper shoes (bare feet are not allowed) to protect feet from sharp objects, falling objects, and chemical spills.

4.5.5 Skin Protection

1. A lab coat or apron should be worn when working with hazardous materials.
2. Never wear shorts in the lab.
3. Always wear clothing that minimizes the amount of skin that can be exposed to potentially harmful chemicals.

4.5.6 Hand Protection

Use gloves made of a material suitable for the operation for any laboratory procedure. Gloves are made of a variety of materials and have specific uses, if used improperly they may not provide the necessary protection. If you have any questions regarding the effectiveness of a glove with a specific chemical visit the glove manufacturer link, for example: http://www.bestglove.com

4.5.7 Respirators

Respirator use should be avoided if at all possible (and is usually not required if adequate precautions are taken). Fume hoods provide constant respiratory protection in all laboratories in the building. Such protection is adequate for most controlled experiments in using the hoods in the building.

4.5.8 Hoods

The most important laboratory equipment is the chemical fume hood, because it is considered the first line of defense against exposure to hazardous chemicals. A Laboratory engineer should check fume hoods at least once annually. However, lab personnel may request more frequent performance checks, particularly when the fan/motor is serviced. Where present, face velocity monitors are recalibrated at the same time. When a fume hood is suspected of breaking down, call the Service Desk/ Maintenance Department at **03-7138000** for repair.

4.6. Safety Equipment

The following safety equipment should be in available in each lab:

- Two fire extinguishers
- Emergency showers and eyewash stations

- A first aid kit (which the research group is responsible for restocking with items purchased at the stockroom)
- A flashlight for use in case of a power failure

4.6.1 Fume hoods

The following guidelines should be followed whenever a chemical fume hood is being used:

- ***Vertical sash hoods***

Use the chemical fume hood with the vertical sash lowered to 18" or the indicated operating height. The operating height should be clearly marked by arrows on yellow tags located on either side of the sash track. Do not work in the hood with the hood sash fully open. To be effective, the fume hood must be operated with the sash at the designated operating height. This will allow the sash to serve as a physical barrier between your face and the contents of the fume hood in case of explosion or fire.

- ***Horizontal sash hoods***

Use the chemical fume hood with the horizontal sashes in place to serve as a physical barrier between your face and the hood contents.

- ***Proper hood operation***
  - Keep the sashes glass clean. Never obstruct your view with paper, notices, decals, or other items on the sashes.
  - Do not place equipment or chemicals close to the slot openings in the baffles at the rear of the hood, or close to the front edge of the hood.
  - Avoid sudden movements while working in the hood.
  - Perchloric acid can leave explosive residues in a fume hood, duct system, or on a hood fan. Perchloric acid can also form explosive mixtures with organic compounds. For this reason, the use of perchloric acid in fume hoods must be carefully evaluated prior to use.

4.6.2 Fire extinguishers

Two sets of fire protection equipment must be available in each lab at two different locations. The extinguishers should be tested and maintained in accordance with the applicable UAE Standards.

4.6.3 Emergency showers and eyewash stations

- Each faculty laboratory or workplace should have approved emergency eye or eye /face wash equipment.
- The equipment should be located within the laboratory and as close as possible to the hazard and be easily accessible.
- These units are required to be accessible in locations that are within 30 m of the hazard and require no more than 10 seconds for the injured person to reach.
- Lab personnel are required to check their eyewash stations monthly and document it to ensure the units are functional.
- Flush off eyewash stations weekly if recommended.

- In the event of contact with a chemical or substance, immediately irrigate the eyes and/or other parts of the body for 15 minutes. Medical attention must be sought immediately.

4.6.4 First aid kits

1. First aid kits are to be used for the immediate response to minor injuries, such as cuts or minor burns and should be located in accessible places (with location clearly marked) in the laboratory.
2. A Lab Engineer/Technician should be responsible for monitoring and maintaining the first aid kit(s).
3. First aid kit contents should include items such as Band-Aids, sterile gauze pads, bandages, scissors, antiseptic wipes or ointments, and a first aid card. All kits should also contain examination gloves for response to emergencies in which blood is present.
4. An emergency electrical response board should be available in Laboratories where ***high-voltage*** equipment is in use. This will contain an instruction card and a non-conductive stick to turn off the equipment and remove the shock victim from contact with the source.

4.6.5 Explosion-proof refrigerators

If there is a need to refrigerate a substance that is flammable, it shall be refrigerated in an approved explosion-proof refrigerator. This refrigerator is designed as such that any flammable vapors in the refrigerator do not contact sparks. This refrigerator must **not** be used for the storage of food.

4.6.6 Specialized local ventilation

Some instruments such as atomic absorption spectrophotometers (AA's) or inductively coupled argon spectrometers (ICP's) emit small quantities of hazardous materials during use. To prevent excessive accumulations of these materials, each of these instruments should be provided with an individual ventilation exhaust duct (as required by the manufacturer). Gas chromatography equipment using thermal conductivity detection should be kept in a hood or have a vent over the column outlets.

4.6.7 Safety shields

Equipment that might cause high explosions, implosions or splash hazards should be protected using safety shields. Laboratory equipment should be shielded on all sides so that there is no line-of-sight exposure of personnel.

Portable shields can be used to protect against hazards of limited severity, e.g., small splashes, heat, and fires.

4.6.8 Biological safety cabinets (if needed)

Biological Safety Cabinets (BSCs) are primary containment devices used in laboratories for working safely with bio-hazardous agents. BSCs use High Efficiency Particulate Air (HEPA) filters to control airborne particles and may be ventilated into the room or ducted out of the building. BSCs must be tested and certified when first installed. On an annual basis, and whenever they are moved, the campus-contracted testing firm tests and certifies BSC's. More details about BSC is presented in section 6.5.1

4.6.9 Respirators

See Personal Protection Section, respirators section 4.5.7

5

CHEMICAL HAZARDS

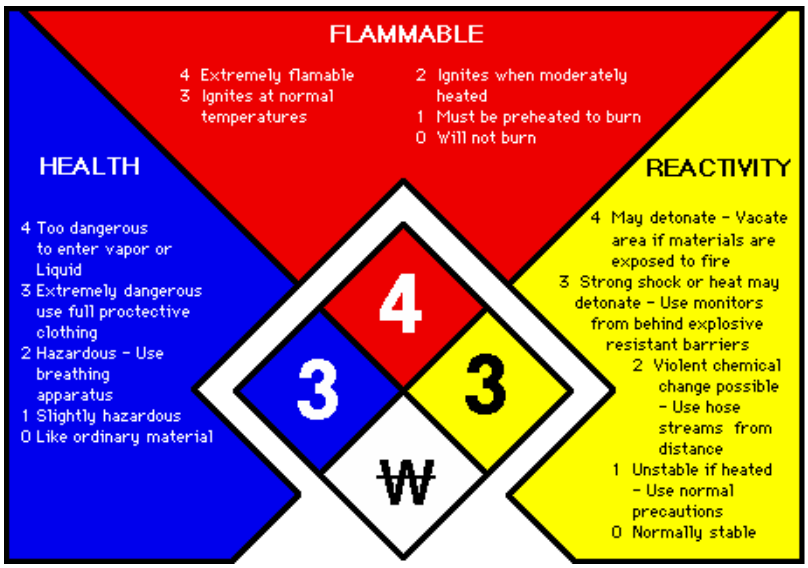
5. CHEMICAL HAZARD

5.1 Introduction

The specific rules and procedures for working with hazardous chemicals, as outlined in Chapter 5, give insight into the proper methods for handling materials, which pose significant hazards due primarily to their chronic toxicity. However, these specific rules and procedures, along with the general rules for working with chemicals, do not address some of the basic physical hazards, which may stem from acute exposure to different types of laboratory chemicals. This chapter offers some specific guidelines for working with common laboratory chemicals that, for varying reasons, are acutely toxic in the sense that they may cause considerable harm to human life and health pending short-term exposures. The Chapter addresses five fundamental classes of laboratory chemicals: flammables, corrosives, oxidizers, reactive, and compressed gases. These classes of chemicals may include chemicals that are also covered in the previous section regarding their property of toxicity.

The National Fire Protection Association (NFPA) has developed a color-coded, numerical system for indicating the **Health (Blue)**, **Flammability** (**Red**) and **Instability or Reactivity** (**Yellow**) hazards of chemicals. In addition, a special precaution symbol (white) may be used if necessary. NFPA labels are **required** on all chemicals in the laboratory. Some purchased chemicals already have these markings (or their equivalents) on the container. Other ones don't have such markings and should have a NFPA label put on them **immediately**

The degree of hazard associated with a particular substance ranges between 0 to 4 with 4 being extremely dangerous and 0 indicates no harm. The degree and type of hazard are summarized in the following chart and the descriptive summary table below. Hazard ratings for common laboratory chemicals are listed in **Appendix IV**.



Health Hazard (Blue)

No Health Hazards: Material offers no health hazard.

Gases, liquids, vapors: LC50 >10,000 ppm

0 *Dusts & Mists:* LC50 >200 mg/L

Materials: Dermal LD50 >2000 mg/kg

Oral LD50 >2000 mg/kg

Nonirritating to skin, eye, or respiratory tract

Significant Irritation: Material only slightly hazardous to health. Exposure could cause irritation if not treated.

Gases, liquids, vapors: LC50 >5000 ppm and ≤ 10,000 ppm

1 *Dusts & Mists:* LC50 >10 mg/L and ≤ 200 mg/L

Materials: Dermal LD50 >1000 mg/kg and ≤ 2000 mg/kg

Oral LD50 >500 mg/kg and ≤ 2000 mg/kg

Mild skin, eye, or respiratory tract irritants

2 **Temporary Incapacitation/Residual Injury:** Exposure could cause injury. Exposure requires prompt treatment. Appropriate protective equipment should be worn.

Gases, liquids, vapors: LC50 >3000 ppm and ≤ 5000 ppm

Dusts & Mists: LC50 >2 mg/L and ≤ 10 mg/L

Materials: Dermal LD50 >200 mg/kg and ≤ 1000 mg/kg

Oral LD50 >50 mg/kg and ≤ 500 mg/kg

Skin, eye, or respiratory tract irritants

Serious or Permanent Injury: Exposure could cause serious injury. Appropriate protective equipment should be worn.

Gases, liquids, vapors: LC50 >1000 ppm and ≤ 3000 ppm

Dusts & Mists: LC50 >0.5 mg/L and ≤ 2 mg/L

Materials: Dermal LD50 >40 mg/kg and ≤ 200 mg/kg

Oral LD50 >5 mg/kg and ≤ 50 mg/kg

Corrosive to skin, eyes, respiratory tract

Lethal: Could cause serious injury or death. Only special protective equipment designed specifically to protect against the specific hazard should be worn.

Gases, liquids, vapors: LC50 ≤ 1000 ppm

Dusts & Mists: LC50 ≤ 0.5 mg/L
Materials: Dermal LD50 ≤ 40 mg/kg

Oral LD50 ≤ 5 mg/kg

Flammability Hazard (Red) – See also **Table 4.2**

Will not burn.

Ignites after considerable heating.

Ignites if moderately heated.

Can be ignited at all normal temperatures.

4 Very flammable gases or very volatile flammable liquids.

Instability or Reactivity Hazard (Yellow)

0 Stable under fire conditions; Does not react with water

1 **Unstable if heated:** Reacts vigorously with water; Changes or decomposes on exposure to light, air, or moisture; Unstable at elevated temperatures and pressure.

2 **Violent chemical change:** Reacts violently with water or forms potentially explosive mixtures with water; Undergoes violent chemical change at elevated temperature and pressure

3 **Shock and heat may detonate:** Requires initiation source; Sensitive to thermal or mechanical shock; Reacts explosively with water without heat or confinement.

4 **May detonate:** Unstable at normal temperature and pressure

Special Notice Key (White): Include symbols when the following hazards are present

~~W~~ Water Reactive

OX Oxidizing Agent

Special precaution symbols:

 **Flammable**

 **Explosive**

 **Corrosive**

 **Poison**

 **Radioactive**

 **Compressed Gas**

Example: If these are the chemicals in your laboratory,

Chemical	H	F	I	Spec
Acetone	1	3	0	

Chromic Acid	**3**	**0**	**1**	OX
Calcium	**3**	**1**	**2**	~~W~~
Ethanol	**0**	**3**	**0**	
Hydrochloric Acid	**3**	**0**	**0**	
Nitric Acid	**3**	**0**	**0**	OX

your NFPA 704 signage should look like this.

HAZARD RATING

5.2 Flammable solvents

Flammable liquids are the most common chemicals found in a laboratory. The primary hazard associated with flammable liquids is, of course, their ability to readily ignite and burn. One should note that it is the vapor of a flammable liquid, not the liquid itself that ignites and causes a fire. Examples of flammable liquids are acetone, ethyl ether, toluene, methyl formate, among others. In general, the vapors of many flammables are irritating to mucous membranes of the respiratory system and eyes, and in high concentrations are narcotic.

1. The rate at which a liquid vaporizes is a function of its *vapor pressure*. In general, liquids with high vapor pressures evaporate at a higher rate compared to liquids of lower vapor pressure. It should be noted that the vapor pressure increases rapidly as the temperature is raised, as does the evaporation rate. A reduced-pressure environment also accelerates the rate of evaporation.
2. The *flash point* of a liquid is the lowest temperature at which a liquid gives off vapor at such a rate as to form an air: vapor mixture that will ignite, but will not sustain ignition. Many commonly used flammable solvents have flashpoints significantly lower than room temperature:

Compound	**Flash Point (°C)**
diethyl ether	-45.0
acetone	-17.8
isopropyl alcohol	11.7

3. The *limits of flammability or explosivity* define the range of fuel air mixtures that will sustain combustion. The lower limit of this range is called the *Lower Explosive Limit* or LEL, and the higher limit of this range is called the *Upper Explosive Limit* or UEL. Materials with very broad flammability ranges (e.g., acetylene, LEL = 3%, UEL = 65%) are particularly treacherous due to the fact that virtually any fuel air combination may form an explosive atmosphere.
4. The *vapor density* of a flammable material is the density (mass to volume ratio) of the corresponding vapor relative to air under specific temperature and pressure conditions. Flammable vapors with densities greater than unity (and thus “heavier” than air) are potentially lethal because they will accumulate at floor level and flow, with remarkable ease, in much the same manner that a liquid would. The obvious threat is that these mobile vapors may eventually reach an ignition source, such as an electrical outlet or a Bunsen burner at another student’s bench

5.2.1 Use and storage

1. Flammable liquids that are not in active use must be stored in safe containers inside fire resistant storage cabinets designed for flammables, or inside storage rooms.
2. Minimize the amount of flammable liquids stored in the lab.
3. Use flammables only in areas free of ignition sources.
4. The transfer of material to or from a metal container is generally accompanied by an accumulation of static charge on the container. This fact must be kept in mind when transferring flammable liquids, since the discharge of this static charge could generate a spark, thereby igniting the liquid. To make these transfers safer, flammable liquid dispensing and receiving containers must be bonded together before pouring. Large containers such as drums must also be grounded when used as dispensing or receiving vessels. All grounding and bonding connections must be metal to metal. (The aforementioned bonding and grounding wires may be found in most lab safety catalogs.)
5. Never heat flammables with an open flame. Instead, use steam baths, water baths, oil baths, hot air baths, sand baths or heating mantles.
6. Do not store flammable liquids in a refrigerator unless it is approved for such storage. Such refrigerators are designed with non-sparking components to avoid an explosion.

5.2.2 First aid

Inhalation Exposures	• Remove person from the contaminated area if it is safe to do so. • Get medical attention and do not leave person unattended.
Ingestion Exposures	• Remove the person, if possible, from the source of contamination. • Get medical attention
Dermal Exposures	• Remove person from source of contamination. • Remove clothing, jewelry, and shoes from the affected areas. Flush the affected area with water for at least 15 minutes. • Obtain medical attention.
Eye Contact	• Remove person from the source of contamination. • Flush the eyes with water for at least 15 minutes. • Obtain medical attention.

5.2.3 Personal protective equipment

Always use a fume hood while working with flammable liquids. Nitrile and neoprene gloves are effective against most flammables. Wear a non-flammable lab coat to provide a barrier to your skin and goggles if splashing is likely to occur (also see Appendix XI for glove information).

5.3 Oxidizers

Oxidizers or oxidizing agents present fire and explosion hazards on contact with combustible materials. Depending on the class, an oxidizing material may increase the burning rate of combustibles with which it comes in contact; cause spontaneous ignition of combustibles with which it comes in contact; or undergo an explosive reaction when exposed to heat, shock, or friction. Oxidizers are generally corrosive and many are highly toxic... Some examples of common oxidizers include peroxides, nitrites, nitrates, perchlorates, chlorates, chlorites, hypochlorites, dichromates, among others.

5.2.1 Use and storage

1. In general, store oxidizers away from flammables, organic compounds, and combustible materials.
2. Strong oxidizing agents like chromic acid should be stored in glass or some other inert container, preferably unbreakable. Corks and rubber stoppers should not be used.
3. Reaction vessels containing appreciable amounts of oxidizing material should never be heated in oil baths, but rather on a heating mantle or sand bath.

5.2.2 Use and storage of perchloric acid

Perchloric acid is an oxidizing agent of particular concern. The oxidizing power of perchloric acid increases with an increase in concentration and with an increase in temperature. Cold, 70% perchloric acid is a strong, non-oxidizing corrosive. A 72% perchloric acid solution at elevated temperatures is a strong oxidizing agent. An 85% perchloric acid solution is a strong oxidizer at room temperature.

1. Do not attempt to heat perchloric acid if you do not have access to a properly functioning perchloric acid fume hood. Perchloric acid can only be heated in a hood specially equipped with a wash-down system to remove any perchloric acid residue. The hood should be washed down after each use and it is preferred to dedicate the hood to perchloric acid use only.
2. Whenever possible, substitute a less hazardous chemical for perchloric acid.
3. Perchloric acid can be stored in a perchloric acid fume hood. Keep only the minimum amount necessary for your work. Another acceptable storage site for perchloric acid is on a metal shelf or in a metal cabinet away from organic or flammable materials. A bottle of perchloric acid should also be stored in a glass secondary container to contain leakage.
4. Do not allow perchloric acid to come in contact with any strong dehydrating agents such as sulfuric acid. The dehydration of perchloric acid is a severe fire and explosion hazard.
5. Do not order or use anhydrous perchloric acid. It is unstable at room temperature and can decompose spontaneously with a severe explosion. Anhydrous perchloric acid will explode upon contact with wood.

5.2.3 First aid

In general, if a person has inhaled, ingested, or come into direct contact with these materials, the person must be removed from the source of contamination as quickly as possible when it is safe to do so. Medical help must be obtained. In the case of an exposure directly to the skin or eyes it is imperative that the exposed person be taken to an emergency shower or eyewash immediately. Flush the affected area for a minimum of 15 minutes, and then get medical attention.

5.2.4 Personal protective equipment

In many cases, the glove of choice will be neoprene, polyvinyl chloride (PVC), or nitrile. Be sure to consult a glove compatibility chart to ensure the glove material is appropriate for the particular chemical you are working with (see Appendix XI for information on glove suitability and availability).

Goggles must be worn if the potential for splashing exists or if exposure to vapor or gas is likely.

Always use these materials in a chemical fume hood as most pose a hazard via inhalation. Cylinders of compressed gases should be kept in ventilated cabinets.

5.3 Corrosives

5.4.1 General characteristics

1. Corrosives are most commonly acids and alkalis, but many other materials can be severely damaging to living tissue.
2. Corrosives can cause visible destruction or irreversible alterations at the site of contact. Inhalation of the vapor or mist can cause severe bronchial irritation. Corrosives are particularly damaging to the skin and eyes.
3. Certain substances considered non-corrosive in their natural dry state are corrosive when wet such as when in contact with moist skin or mucus membranes. An example of these materials is lithium chloride, halogen fluorides, and allyl iodide.
4. Sulfuric acid is a very strong dehydrating agent and nitric acid is a strong oxidizing agent. Dehydrating agents can cause severe burns to the eyes due to their affinity for water.
5. Examples of corrosives include sulfuric acid, chromic acid, ammonium bifluoride, bromine, ammonium hydroxide, among others.

All corrosives possess the property of being severely damaging to living tissues and also attack other materials such as metal. Skin contact with alkali metal hydroxides, e.g., sodium hydroxide and potassium

hydroxide, is more dangerous than with strong acids. Contact with alkali metal hydroxides normally causes deeper tissue damage because there is less pain than with an acid exposure. The exposed person may not wash it off thoroughly enough or seek prompt medical attention.

All hydrogen halides are acids that are serious respiratory irritants and also cause severe burns. Hydrofluoric acid is particularly dangerous. At low concentrations, hydrofluoric acid does not immediately show any signs or symptoms upon contact with skin. It may take several hours for the hydrofluoric acid to penetrate the skin before you would notice a burning sensation. However, by this time permanent damage, such as second and third degree burns with scarring, can result.

5.4.2 Use and storage

1. Always store acids separately from bases. Also, store acids in acid storage cabinets away from flammables since many acids are also strong oxidizers.
2. Do not work with corrosives unless an emergency shower and continuous flow eyewash are available.
3. Add acid to water, but never add water to acid. This is to prevent splashing from the acid due to the generation of excessive heat as the two substances mix.
4. Never store corrosives above eye level. Store on a low shelf or cabinet.
5. It is a good practice to store corrosives in a tray or bucket to contain any leakage.
6. When possible, purchase corrosives in containers that are coated with a protective plastic film that will minimize the danger to personnel if the container is dropped.
7. Store corrosives in a wooden cabinet or one that has a corrosion-resistant lining. Corrosives stored in an ordinary metal cabinet will quickly damage it. If the cabinet supports that hold up the shelves become corroded, the result could be serious. Acids should be stored in acid storage cabinets specially designed to hold them and Nitric acid should be stored in a separate cabinet or compartment

5.4.3 Use and storage of hydrofluoric acid

1. Hydrofluoric acid is extremely hazardous and deserves special mention. Hydrofluoric acid can cause severe burns and inhalation of anhydrous hydrogen fluoride can be fatal. Initial skin contact with hydrofluoric acid may not produce any symptoms.
2. Only persons fully trained in the hazards of hydrofluoric acid should use it.
3. Always use hydrofluoric acid in a properly functioning fume hood. Be sure to wear personal protective clothing!

4. If you suspect that you have come in direct contact with hydrofluoric acid: wash the area with water for at least 15 minutes, remove clothing, and then promptly seek medical attention. If hydrogen fluoride vapors are inhaled, move the person immediately to an uncontaminated atmosphere (if safe to do so), keep the person warm, and seek prompt medical attention.
5. Never store hydrofluoric acid in a glass container because it is incompatible with glass.
6. Store hydrofluoric acid separately in an acid storage cabinet and keep only that amount necessary in the lab.
7. Creams for treatment of hydrofluoric acid exposure are commercially available.

5.4.4 First Aid

Inhalation	• Remove person from source of contamination if safe to do so. • Get medical attention. • Keep person warm and quiet and do not leave unattended.
Ingestion	• Remove person from source of contamination. • Get medical attention and inform emergency responders of the name of the chemical swallowed.
Skin Contact	• Remove person from source of contamination and take immediately to an emergency shower or source of water. • Remove clothing, shoes, socks, and jewelry from affected areas as quickly as possible, cutting them off if necessary. • Be careful not to get any chemical on your skin or to inhale the vapors. • Flush the affected area with water for a minimum of 15 minutes. Get medical attention.
Eye Contact:	• Remove person from source of contamination and take immediately to an eyewash or source of water. • Rinse the eyes for a minimum of 15 minutes. • Have the person look up and down and from side to side. Get medical attention. • Do not let the person rub their eyes or keep them tightly shut.

5.4.5 Personal protective equipment

Always wear the proper gloves when working with acids. Neoprene and nitrile gloves are effective against most acids and bases. Polyvinyl chloride (PVC) is also effective for most acids. A rubber coated apron and goggles should also be worn. If splashing is likely to occur, wear a face shield over the goggles. Always use corrosives in a chemical fume hood.

5.5 Reactive Chemicals

5.5.1 General characteristics

Reactive chemicals are grouped as a category primarily because of the safety hazards associated with their use and storage and not because of similar acute or chronic health effects. For health hazard information on specific reactive materials consult the MSDSs, or the manufacturer. However, there are some hazards common to the use of reactive materials. Injuries can occur due to heat or flames, inhalation of fumes, vapors, and reaction products, and flying debris.

Polymerization reactions:

Polymerization is a chemical reaction in which two or more molecules of a substance combine to form repeating structural units of the original molecule. This can result in an extremely high or uncontrolled release of heat. An example of a chemical which can undergo a polymerization reaction is styrene.

Water reactive materials:

1. When water reactive materials come in contact with water, one or more of the following can occur: liberation of heat which may cause ignition of the chemical itself if it is flammable, or ignition of flammables that are stored nearby; release of a flammable, toxic, or strong oxidizing gas; release of metal oxide fumes; and formation of corrosive acids.
2. Water reactive chemicals can be particularly hazardous to firefighting personnel responding to a fire in a lab, because water is the most commonly used fire extinguishing medium. Examples of water reactive materials include lithium, sodium, potassium, magnesium, zinc, alkyl aluminums, among others.

Pyrophorics:

Pyrophoric materials can ignite spontaneously in the presence of air. Examples of pyrophoric materials include diethyl zinc triethyl aluminum many organometallic compounds

Peroxide-forming materials:

Peroxides are very unstable and some chemicals that can form them are commonly used in laboratories. This makes peroxide-forming materials some of the most hazardous substances found in a lab. Peroxide-forming materials are chemicals that react with air, moisture, or impurities to form peroxides. The tendency

to form peroxides by most of these materials is greatly increased by evaporation or distillation. Organic peroxides are extremely sensitive to shock, sparks, heat, friction, impact, and light. Many peroxides formed from materials used in laboratories are more shock sensitive than TNT. Just the friction from unscrewing the cap of a container of an ether that has peroxides in it can provide enough energy to cause a severe explosion. Examples of peroxide-forming materials (the first group listed is the most hazardous): di-isopropyl ether divinyl acetylene, sodium amide, potassium amide, dioxane diethyl ether, tetrahydrofuran vinyl ethers, acrylonitrile styrene, among others

Other shock-sensitive materials:

These materials are explosive and sensitive to heat and shock. Examples of shock-sensitive materials: chemicals containing nitro groups, fulminates, hydrogen peroxide (30%+), ammonium perchlorate, benzoyl peroxide (when dry), compounds containing the functional groups: acetylide, azide, diazo, halamine, nitroso, and ozonide.

5.5.2 Use and storage

1. A good way to reduce the potential risks is to minimize the amount of material used in the experiment. Use only the amount of material necessary to achieve the desired results.
2. Always substitute a less hazardous chemical for a highly reactive chemical whenever possible. If it is necessary to use a highly reactive chemical, order only the amount that is necessary for the work.
3. Store water-reactive chemicals in an isolated part of the lab. A cabinet far removed from any water sources, such as sinks, emergency showers, and chillers, is an appropriate location. Clearly label the cabinet “Water-Reactive Chemicals – No Water”.
4. Store pyrophorics in an isolated part of the lab and in a clearly marked cabinet. Be sure to routinely check the integrity of the container and have the material disposed of through EH&S if the container is corroded or otherwise damaged.
5. Do not open the chemical container if peroxide formation is suspected. The act of opening the container could be sufficient to cause a severe explosion. Visually inspect liquid peroxide-forming materials for crystals or unusual viscosity before opening. Pay special attention to the area around the cap. Peroxides usually form upon evaporation, so they will most likely be formed on the threads under the cap.
6. Date all peroxide forming materials with the date received, and the expected shelf life. Chemicals such as di-isopropyl ether, divinyl acetylene, sodium amide, and vinylidene chloride should be discarded after three months. Chemicals such as dioxane, diethyl ether, and tetrahydrofuran should be submitted to EH&S for disposal after one year.

7. Store all peroxide-forming materials away from heat, sunlight, and sources of ignition. Sunlight accelerates the formation of peroxides.
8. Secure the lids and caps on containers of peroxide-forming materials to discourage the evaporation and concentration of these chemicals.
9. Never store peroxide-forming materials in glass containers with screw cap lids or glass stoppers. Friction and grinding must be avoided. Also, never store these chemicals in a clear glass bottle where they would be exposed to light.
10. If you notice crystal formation in the container or around the cap, do not attempt to open or move the container. Proper disposal should be carried out.
11. Never distill an ether unless it is known to be free of peroxides.
12. Store other shock sensitive materials separately from other chemicals and in a clearly labeled cabinet.
13. Never allow picric acid to dry out, as it is extremely explosive. Always store picric acid in a wetted state.

5.5.3 First aid

1. If someone is seriously injured the most important step to take is to contact emergency responders as quickly as possible. This is best accomplished by directly calling Civil Defense at **9-997**. Explain the situation and describe the location clearly and accurately.
2. If someone is severely bleeding, apply a sterile dressing, clean cloth, or handkerchief to the wound. Then put protective gloves on and place the palm of your hand directly over the wound and apply pressure and keep the person calm. Continue to apply pressure until help arrives.
3. If a person's clothes are on fire, he or she should drop immediately to the floor and roll. If a fire blanket is available, put it over the individual. An emergency shower, if one is immediately available, can also be used to douse flames.
4. If a person goes into shock, have the individual lie down on their back if safe to do so and raise the feet about one foot above the floor.

5.5.4 Personal protective equipment

1. Wear appropriate personal protective clothing while working with highly reactive materials. This might include: impact resistant safety glasses or goggles, a face shield, gloves, a lab coat (to minimize injuries from flying glass or an explosive flash), and a shield.

2. Conduct work within a chemical fume hood as much as possible and pull down the sash as far as is practical. While the experiment does not require you to reach into the fume hood, keep the sash closed.
3. Barriers can offer protection of personnel against explosions and should be used. Many safety catalogs offer commercial shields which are commonly polycarbonate and are weighted at the bottom for stability. It may be necessary to secure the shields firmly to the work surface

5.6 Compressed Gas Cylinders

Cylinders of compressed gases can pose a chemical as well as a physical hazard. If the valve were to break off a cylinder, the amount of force present could propel the cylinder through a brick wall.

Use and storage

1. Whenever possible, use flammable and reactive gases in a fume hood or other ventilated enclosure. Certain categories of toxic gases must always be stored and used in ventilated enclosures.
2. Always use the appropriate regulator on a cylinder. If a regulator will not fit a cylinder's valve, replace the cylinder, not the regulator. Do not attempt to adapt or modify a regulator to fit a cylinder it was not designed for. Regulators are designed to fit only specific cylinder valves to avoid improper use.
3. Inspect regulators, pressure relief devices, valves, cylinder connections, and hose lines frequently for damage.
4. Never use a cylinder that cannot be positively identified. Color-coding is not a reliable way of identifying a cylinder because the colors can vary from supplier to supplier.
5. Do not use oil or grease on any cylinder component of an oxidizing gas because a fire or explosion can result.
6. Never transfer gases from one cylinder to another. The gas may be incompatible with the residual gas remaining in the cylinder or may be incompatible with the cylinder material.
7. Never completely empty cylinders during lab operations; rather, leave approximately 25 psi of pressure. This will prevent any residual gas in the cylinder from becoming contaminated.
8. Place all cylinders so that the main valve is always accessible.
9. Close the main cylinder valve whenever the cylinder is not in use.
10. Remove regulators from unused cylinders and always put the safety cap in place to protect the valve.

11. Always secure cylinders, whether empty or full, to prevent them from falling over and damaging the valve (or falling on your foot). Secure cylinders by chaining or strapping them to a wall, lab bench, or other fixed support.
12. Oxygen should be stored in an area that is at least 6 m away from any flammable or combustible materials or separated from them by a non-combustible barrier at least 2 m high and having a fire-resistance rating of at least 1/2 hour.
13. To transport a cylinder, put on the safety cap and strap the cylinder to a hand truck in an upright position. Never roll a cylinder.
14. Always clearly mark empty cylinders and store them separately.
15. Be careful while handling compressed gas cylinders and never drop or strike a cylinder against anything.
16. Use only wrenches or other tools supplied by the cylinder supplier to open a valve. Open cylinder valves slowly.
17. Only compatible gases should be stored together in a gas cylinder cabinet.
18. Flammable gases must be stored in properly labeled, secured areas away from possible ignition sources and kept separate from oxidizing gases.
19. Do not store compressed gas cylinders in areas where the temperature can exceed 50 ^{o}C.

6

BIOLOGICAL HAZARDS

6. BIOLOGICAL HAZARD

6.1 Introduction

Microbiological and biohazard laboratories are special, often unique, work environments that may pose special risks to persons in or near them. Biohazards are biological agents or substances present in or arising from the work environment. Biological agents and substances include infectious and parasitic agents, noninfectious microorganisms, such as some fungi, yeast, algae, plants and plant products, and animals and animal products that cause occupational disease. Generally, biohazards are either:

1. Infectious microorganisms
2. Toxic biological substances
3. Biological allergens
4. Any combination of the above

Personnel have contracted infections in the laboratory throughout the history of microbiological and biohazard research. A number of cases have been attributed to carelessness or poor technique in the handling of biohazard materials.

The term "containment" is used in describing safe methods for managing biohazards in the laboratory environment where they are being handled or maintained. Primary containment, the protection of personnel and the immediate laboratory environment from exposure to biological agents, is provided by good microbiological technique and the use of appropriate safety equipment. The use of vaccines may provide an increased level of personal protection. Secondary containment, the protection of the environment external to the laboratory from exposure to biohazard materials, is provided by a combination of facility design and operational practices. The purpose of containment is to reduce exposure of laboratory workers and other persons, and to prevent escape into the outside environment of potentially hazardous agents. The three elements of containment include laboratory practice and technique, safety equipment, and facility design.

6.2. Routes of Exposure

There are four main routes of exposure that one must try to avoid when working with bio-hazardous agents in the laboratory. These would include percutaneous injuries, inhaling infectious aerosols, exposure to mucous membranes, and ingestion.

Percutaneous injuries can result from needle sticks, cuts or abrasions from contaminated items. These exposures are particularly serious because of the potential for immediate entry of the agent into a normally sterile bloodstream. All sharps items should be handled and disposed of appropriately.

Many laboratory procedures can cause the aerosolization of infectious agents. Some of these procedures include the use of vortexes, blenders and sonicators. Proper work practices must be implemented to minimize the aerosolization of all materials, especially those which are known to be transmitted by the aerosol route (e.g., Adenovirus, Vaccinia virus, *Mycobacterium tuberculosis*, etc.).

Exposure of mucous membranes to infectious agents can lead to occupationally acquired infections. Mucocutaneous exposures can result from splashes to the eyes, nose or mouth, or by inadvertent inoculation via contaminated hands. Face protection should always be used if there is any likelihood of splash or splatter.

Accidental ingestion of bio-hazardous materials can result from improper personal hygiene in the laboratory. Food and drink are prohibited in all areas of the laboratory in which work is conducted with potentially infectious materials. Hands must always be washed before leaving the laboratory, and immediately if visible contamination occurs.

6.3. General Safety Requirements

6.3.1 Eating, Drinking, Smoking

Eating, drinking, smoking, applying cosmetics, and handling contact lenses are prohibited in work areas in which potentially infectious materials are being manipulated. A burning cigarette, cigar, or pipe is an ignition source to flammable solvents.

6.3.2 Food storage

Not permitted in refrigerators where any reagents or samples are stored.

6.3.3 Contact lenses

It is strongly recommended that contacts not be worn in the laboratory. If contacts are worn, notify the person in charge.

6.3.4 Face shield or eye protection

Must be worn when handling any caustic, acidic material or solvents.

6.3.5 Clothing

Laboratory coats should be worn in the laboratory and removed when out of the laboratory.

6.3.6 Shoes

Should be comfortable and cover the entire foot. Shoes with open toes or sandals are not to be worn in the laboratory.

6.3.7 Hair

Must be secured, back and off the shoulders, to prevent it from coming in contact with contaminate materials or surfaces, moving machinery, and open flames. This also reduces the shedding of microorganisms into the work area.

6.3.8 Hand washing

Hands should be washed as soon as possible when they come in contact with potentially infectious materials. A vigorous hand washing with a mild soap for 10 full seconds is appropriate. Hands should also be washed as soon as feasible after gloves are removed, and before exiting the laboratory.

6.3.9 Pipetting

- Use hand-pipetting devices. Do not use mouth pipette.
- Use pipettes with a cotton plug.

- Pipette contents should be allowed to run down the wall of the container, making sure not to release the contents from a height.
- Place absorbent paper on bench tops to reduce the risk of aerosols being generated by accidental dripping of infectious materials from pipette tips.
- Contaminated pipettes should be placed horizontally in a pan or a vertical pipette holder containing enough disinfectant to allow complete immersion.
- The pan and pipettes should be autoclaved as a unit and replaced by a clean pan with fresh disinfectant.

6.3.10 Exits and aisles

- Must be clear at all times. No equipment, chairs, stools, supplies or trash are permitted in exit routes.
- Doors to the laboratory should be kept closed. Exit doors must not be blocked, bolted or obstructed in any way to prevent a rapid exit.

6.3.11 Housekeeping

- Cleaning cloths or flammable solvents are to be disposed of in self-closing metal containers.
- Never hang clothes on or near radiators, steam pipes, heating instruments, or open flames.
- Do not allow trash to accumulate in any area. Trash should be disposed of daily or more frequently, if necessary.
- All infectious or toxic materials, and associated equipment or apparatus should be autoclaved or otherwise sterilized before being washed or discarded.
- Equipment which may become contaminated with blood or other potentially infectious materials should be checked routinely and prior to servicing or shipping and shall be decontaminated as necessary.
- All bins, pails, cans, and similar receptacles intended for re-use which have a potential for becoming contaminated with blood or other potentially infectious materials should be inspected, cleaned, and disinfected on a regularly scheduled basis and cleaned and disinfected immediately or as soon as possible upon visible contamination.
- Infectious or toxic material should not be placed in an autoclave overnight in anticipation of autoclaving the next day.
- Work benches should be kept as clutter-free as feasible.

- Floors, laboratory benches and other surfaces should be decontaminated with an appropriate disinfectant after completion of procedures; when surfaces are overtly contaminated; immediately after the spill of blood or other potentially infectious materials; and at the end of the work shift.
- Protective coverings such as plastic wrap, aluminum foil, or imperviously-backed absorbent paper may be used to cover equipment and environmental surfaces. These coverings shall be removed and replaced at the end of the work shift or when they become overtly contaminated.
- Broken glassware which may be contaminated should not be picked up directly with the hands. It should be cleaned up using mechanical means such as a brush and dust pan, tongs, cotton swabs or forceps.
- Specimens of blood or other potentially infectious materials should be placed in a closable, leak-proof container labeled or color-coded bag prior to being stored or transported. If outside contamination of the primary container is likely, then a second leak-proof container that is labeled or color-coded shall be placed over the outside of the first container and closed to prevent leakage during handling, storage, or transport. If puncture of the primary container is likely, it should be placed in a leak-proof puncture-resistant secondary container.

6.3.12 Glassware

- Use only unbroken and unchipped glassware.
- Do not leave pipettes sticking out of bottles, flasks or beakers.
- Do not attempt to remove stoppers on glass tubing by force.
- Decontaminate glass exposed to samples by heat.
- Dispose of broken glass or other sharp material in a specially marked separate container.

6.3.12 Deep freezers and refrigerators

- Should be checked and cleaned out periodically to remove any broken ampules, tubes, etc. containing toxic or infectious material.
- Use rubber gloves during cleaning.
- All infectious or toxic material stored in refrigerators or deep freezers will be properly labeled.
- Old specimens or samples will be properly discarded when no longer needed.

6.3.13 Centrifuge

- Before centrifuging, inspect tubes for cracks, inspect the inside of the trunnion cup for rough walls caused by erosion or adhering material.

- Do not operate centrifuge unless the cover is closed.
- Do not centrifuge uncovered tubes. Use caps, stoppers, or parafilm.
- An unbalanced head may cause the instrument to vibrate. The operator should check to be sure that heads are symmetrically loaded. Particular attention should be given to verify that swing-out cups are supported correctly.

6.3.14 Autoclaves

- Personnel should only operate the autoclave after receiving proper instructions on operational procedures.
- Open only when the temperature and pressure are back to normal.
- Use heat resistant gloves when putting items into or removing items from the autoclave. The sides and doors may be hot in addition to the materials being autoclaved. **Caution:** Steam may penetrate heat resistant gloves.
- Loosen caps of any container prior to autoclaving to allow equalization of pressure inside container. This prevents explosion, boil over and implosions.
- Disposal of contaminated materials
- Discard specimens and cultures into containers with a double plastic lining. Bags must be changed when about half full.
- Both inner and outer bags should be sealed securely to prevent leakage when half full and during transportation to the autoclave area. Bags should be opened before autoclaving to insure sterilization. After autoclaving and once the material has cooled, the bags must be resealed. The bags then can go into the regular trash.
- Label the outer bag to clearly indicate the nature of the biologic hazard, how to handle it, and who to notify in case of an accidental spill.
- Materials or containers that are to be reused should be autoclaved prior to cleaning. Place them in a sealed and clearly labeled container to minimize hazard to others prior to sterilization.
- Any breakage of bags or leakage of contaminated materials should be reported to the laboratory director or supervisor at once for instructions on procedures for safe cleanup.

6.3.15 Sharps

- The use of needles, glass pipettes, glass slides and cover slips, scalpels and lancets should be eliminated when possible.
- Plastic-ware should be used whenever possible, such as plastic graduated cylinders, funnels, etc.

- Discard needles, syringes, pipettes, broken glassware, glass slides, and scalpel blades into the appropriate container. Make sure that metal and glass/plastics are in separate containers.
- Discard sharps into a suitable plastic or heavy plastic lined container that is properly labeled. If items are not contaminated, the container may then be thrown into the normal trash.
- Do not recap needles.
- Do not use devices that cut needles off. These devices produce an aerosol.
- Do not force sharps into a full container. Use a new container when the old one is full.

6.3.16 Labeling and posting

- Post permanent signs in permanent frames. Post temporary signs (less than one month) with masking tape on glass surfaces or on refrigerators, freezers or doors. Remove all temporary signs when the hazard no longer exists.
- Affix labels with appropriate warnings to all hazardous reagents in addition to the required area label designation.
- All reagents and materials must be labeled by the manufacturer or by the PI in regard to:
    1. Concentration
    2. Date received or prepared
    3. Date placed in service
- All hazardous reagents must be labeled with:
    1. Caution required
    2. Type of hazard (i.e. poison, irritant)
    3. Precautions (i.e. avoid skin contact)
    4. Accident instructions (i.e. wash immediately)

6.3.17 Laundering laboratory clothing

- All laboratory clothing used as protective equipment, should be laundered by the employer at no cost to employees.
- Soiled clothing being collected for laundering should be placed in leak-proof container (e.g., biohazard bag).
- Soiled laundry should only be handled by individuals wearing appropriate PPE.

- Reusable laboratory clothing worn in BSL-3 areas must be decontaminated before being laundered.

6.4. Personal Protective Equipment (PPE)

When there is a potential for occupational exposure, appropriate personal protective equipment shall be used as the primary barrier of protection. PPE may include, but not limited to, gloves, gowns, lab coats, eye and ear protection, booties and respirators. Remarks on the use of PPE are illustrated below:

1. Appropriate PPE in the appropriate sizes shall be readily accessible at the work site.
2. PPE shall be repaired or replaced as needed to maintain its effectiveness.
3. Gloves shall be worn when there is a chance for the hands to have the direct skin contact with blood, other potentially infectious materials, mucous membranes, non-intact skin, and when handling items or surfaces soiled with blood or other potentially infectious material.
    a. Disposable (single-use) gloves such as surgical or examination gloves shall be replaced as soon as possible when visibly soiled, torn, punctured or when their ability to function as a barrier is compromised. They shall not be washed or disinfected for re-use.
    b. Utility gloves may be disinfected for re-use if the integrity of the glove is not compromised, however, they must be discarded if they are cracked, peeling, discolored, torn, punctured, or exhibit other signs of deterioration.
4. Masks and eye protection or chin-length face shields shall be worn whenever splashes, spray, spatter, droplets, or aerosols of blood or other potentially infectious materials may be generated and there is a potential for eye, nose, or mouth contamination.
5. Appropriate protective clothing shall be worn when there is a potential for occupational exposure. The type and characteristics will depend upon the task and degree of exposure anticipated.
    a. Gowns, lab coats, aprons or similar clothing shall be worn if there is a potential for soiling of clothes with blood or other potentially infectious materials.
    b. Fluid resistant clothing, surgical caps or hoods shall be worn if there is a potential for splashing or spraying of blood or other potentially infectious materials.
    c. Fluid-proof shoe covers shall be worn if there is a potential for shoes to become contaminated and/or soaked with blood or other potentially infectious materials.
6. PPE should be removed immediately and replaced if gross contamination of the equipment occurs.
7. PPE should be removed before exiting the laboratory

6.5. Laboratory Equipment

Safety equipment includes biological safety cabinets and a variety of enclosed containers such as the centrifuge cup. Below is a description of this equipment.

6.5.1. Biological safety cabinets (BSCs)

The protection of personnel from aerosols created by experimental procedures is necessary with use of biological agents. The biological safety cabinet is a primary barrier that protects the work by controlling

the aerosols. Biological safety cabinets can only protect the worker and the experiment if they have been properly selected for the intended containment function. Selection is dependent on: (1) the hazard classification of the agent, (2) the need for protection of research material or personnel, and (3) the extent to which hazardous aerosols are involved. There are three basic types of biological safety cabinets. Class I, Class II, and Class III.

Class I Cabinets:

Class I is designed as a partial containment cabinet offering adequate personnel protection but no product or experiment protection. Cross contamination may result from contaminated air flowing over the work area. It is recommended that this type be used for low to moderate risk infectious biological agents.

Class II Cabinets:

Class II provides environmental, personnel and product protection. These cabinets are for procedures that generate aerosols, such as sonicating and blending, with low-risk oncogenic viruses, and for all procedures with moderate-risk oncogenic viruses and Class 3 etiologic agents. The main difference between Class I and II cabinets is the HEPA filtration of the airflow down across the work surface of a Class II cabinet. There are two types of Class II cabinets, Type A and Type B. **Table 6.1** characterizes the differences.

Table 6.1. Types of class II cabinets

.	**Type A**	**Type B**
Front work opening	***Fixed***	***Vertical sliding sash*** [a]
Average vertical airflow velocity	75 ft/min	50 ft/min
Minimum inward flow velocity	75 ft/min	100 ft/min
Volume of air recirculated	70%	30%
Exhaust blowers	Integral	Independent [b]
Positive pressure plenums	Contaminated air	Filtered air

[a] Optimum operating level of 8" opening

[b] Cabinet requires connection to a separate exhaust system incorporated in the facility

Type A cabinets recirculate approximately 70% of the total cabinet air. Do not use Type A cabinets with flammable solvents, toxic agents or radioactive material. Type B cabinets exhaust 70% of the air flowing through the work area, thereby allowing a wider range of chemicals that can be used. Type B cabinets are not recommended for use with explosive vapors. For effective use of Class II cabinets, the following are required:

1. Wash hands well with a germicidal soap before and after work in the cabinet
2. Use gloves and long-sleeve lab coats to avoid shedding of skin flora and for protection
3. Disinfect the interior work surfaces by wiping it down with an appropriate disinfectant
4. Place everything needed for the complete procedure in the cabinet prior to beginning work
5. Keep the front intake or rear exhaust grill free of equipment and material
6. Turn on airflow and wait 5-10 minutes before working after materials are in the cabinet. This allows the cabinet time to purge airborne contaminates from the work areas
7. Minimize traffic in the area during operation of the cabinet. Unnecessary activity may create disruptive air currents
8. Place the Bunsen burner to the rear of the cabinet. The flame can disrupt unidirectional airstream but is minimized by placing the burner to the rear
9. Let the cabinet run for 15 minutes with no activity after completion of work. This allows time for the cabinet to purge air contaminants.
10. Decontaminate the interior surface after removal of all materials
11. Shut down by turning off the fan and lights

Class III:

Class III cabinets are gas tight, closed-front, self-contained, ventilated safety cabinets. They operate at a negative pressure thus providing a physical barrier between the agent and worker. Of all the safety cabinets these provide the greatest degree of personnel protection. Work in these cabinets requires arm length rubber gloves attached to a sealed front panel. Class III systems are used to contain highly infectious materials

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Cabinet certification:

Since contamination control depends on proper mechanical performance, certification is necessary:

- At initial installation and annually thereafter
- After moving a cabinet
- After replacing the HEPA filter

The certification procedure should include:

- Halogen leak test to insure the positive pressure air flow plenums are gas tight
- Measurement of air inflow velocity
- Measurement of the airflow within the cabinet to assure it is uniform and unidirectional
- A leak test of the HEPA filter to verify proper installation and that it is leak-free

Clean benches:

Horizontal laminar-flow clean benches are designed to protect the product from contamination and should never be confused with BSCs! The near-sterile work area makes these devices good for many applications

in which the product does not pose a risk to the worker. “Clean benches” are considered inappropriate for work with potentially infectious agents.

6.5.2. Centrifuges:

Depending on the types of materials being used, safety centrifuges may be necessary to prevent the release of aerosols created during centrifugation. Many types of centrifuges have sealed buckets, safety trunnion cups or sealed heads. Safety cups must be opened in a BSC after centrifugation when working with agents known to be spread via aerosols (e.g. Mycobacterium tuberculosis).

6.5.3. Homogenizers and blenders

These items are commonly used in laboratories, and both are considered producers of aerosols. Safety sealed homogenizers and blenders are commercially available and should be used when working with those agents known or suspected of being transmitted through aerosols. The purpose of these items is to contain any aerosols created during work procedures. These safety devices may be used on the open bench top; however, they must be opened in a BSC. All non-sealed devices must be used exclusively in a BSC.

6.6. Biosafety levels

Biological agents are assigned to biosafety levels (BSL) based on the risk they pose to human health and the environment. Such factors as severity of disease caused by the agent routes of exposure, and virulence are used when determining the most appropriate BSL. The partial list below is provided to assist laboratories in making preliminary decisions on the appropriate biosafety level for particular agents.

There are four biosafety levels (BSLs). Biosafety levels are summarized in **Table 6.2** for proper handling of bio-hazardous materials. The levels are arranged in ascending order by degree of protection provided to personnel, the environment, and the community. BSLs consist of combinations of laboratory practices and techniques, safety equipment, and laboratory facilities. Each combination is specifically appropriate for the operations performed, the documented or suspected routes of transmission of the infectious agents, and for the laboratory function or activity.

Table 6.2. Summary of recommended containment levels for infectious agents

BSL	Agents	Practices	Safety Equipment (Primary Barriers)	Facilities (Secondary Barriers)
1	Not known to cause disease in healthy adults	Standard microbiological practices	None required	Open bench top, sink required

2	Associated with human disease. Hazard: percutaneous injury, mucous membrane exposure, ingestion	BSL-1 practices plus: • Limited access • Biohazard warning sign • Sharps precautions • Biosafety manual defining waste decontamination or medical surveillance policies	Primary barriers: Class I or II biosafety cabinets or other physical containment devices use for all manipulations of agents that cause splashes or aerosols of infectious materials; PPE: laboratory coats, gloves, face protection as needed	BSL-1plus: Autoclave available
3	Indigenous or exotic agents with potential for aerosol transmission; disease may have serious or lethal consequences	BSL-2 practices plus: • Controlled access • Decontamination of all wastes • Decontamination of lab clothing before laundering • Baseline serum	Primary barriers: Class I or II biosafety cabinets or other physical containment devices use for all manipulations of agents; PPE: laboratory coats, gloves, respiratory protection as needed	BSL-2 plus: • Physical separation from access corridors • Self-closing double door access • Exhaust air not recirculated • Negative airflow into laboratory
4	Dangerous/exotic agents which pose high risk of life-threatening disease, aerosol-transmitted lab infections; or related agents with unknown risk of transmission	BSL-3 practices plus: • Clothing change before entering • Shower on exit • All material decontaminated on exit from facility	Primary barriers: All procedures conducted in Class III biosafety cabinets or Class I or II biosafety cabinets in combination with full-body, air supplied positive pressure suit	BSL-3 plus: • Separate building or isolated zone • Dedicated supply/exhaust, vacuum and decontamination system

6.6.1 Biosafety level 1 (BSL-1)

Biosafety Level 1 is suitable for experiments, involving agents of no known or of minimal potential hazard to laboratory personnel and the environment. Examples of BSL-1 agents include: Bacillus subtilis, Escherichia coli k12, Naegleria gruberi, etc. The laboratory is not separated from the general traffic patterns of the building. Work is generally conducted on open bench tops. Special containment equipment is not required or generally used. Laboratory personnel have specific training in the procedures conducted in the laboratory, and are supervised by a scientist with general training in microbiology or a related science. The following standard and special practices apply to agents assigned to Biosafety Level 1:

Standard microbiological practices:

- Laboratory doors are kept closed to limit access when experiments are in progress.

- Work surfaces are decontaminated daily and after any spill of viable material.
- All contaminated liquid or solid wastes are decontaminated before being disposed or otherwise handled.
- Mechanical pipetting devices are used; mouth pipetting is prohibited.
- Eating, drinking, smoking, storing of food, and applying cosmetics are not permitted in the work area.
- All procedures must be carefully performed to minimize the creation aerosols.
- Persons wash their hands, before leaving the lab, after they handle viable material and animal.
- The wearing of laboratory coats, gowns, gloves, eye protection, or uniforms is recommended.
- All cultures, stocks, and other regulated wastes are decontaminated before disposal by an approved decontamination method.
- Contaminated materials that are to be decontaminated at a site away from the laboratory are placed in a durable leak-proof container that is covered before being removed from the laboratory
- An insect and rodent control program are in effect.

Containment equipment:

Special containment equipment is generally not required for manipulations of agents assigned to BSL-1.

Laboratory facilities:

- The laboratory should be designed so that it is easily cleaned.
- Bench tops should be impervious to water and resistant to acids, alkalis, organic solvents and moderate heat.
- Laboratory furniture should be sturdy with spaces between benches and cabinets, and equipment should be accessible for cleaning.
- Each laboratory should contain a hand washing sink, an eye wash station and a shower.
- If the laboratory has windows that open, they should be fitted with fly screens.
- An autoclave for decontamination of infectious laboratory wastes should be available in the same building with the laboratory.

6.6.2 Biosafety level 2 (BSL-2)

Biosafety Level 2 is similar to BSL-1 and is suitable for experiments involving agents of moderate potential hazard to personnel and the environment (See examples below). It differs in that laboratory personnel have specific training in handling pathogenic agents and are supervised by competent scientists. The lab has limited access when experiments are being conducted, and procedures involving large volumes or high concentrations of agents, or in which aerosols are likely to be created, are conducted in biological safety cabinets or other physical containment equipment. Examples of BSL-2 agents are include in **Table 6.3**.

Table 6.3. Biohazard agent under BSL-2

Viral agents	
Adenovirus, Creutzfeldt-Jacob agent, Cytomegalovirus, Eastern equine encephalitis, Epstein-Barr virus, Hepatitis A, B, C, D, E Herpes simplex viruses, HIV	HTLV types I and II, Human Blood & Blood Products, Kuru, Monkeypox virus, SIV, Spongiform encephalopathies, Vaccinia virus, VSV (lab adapted strains)
Bacterial / Rickettsial agents	
Campylobacter fetus, coli, jejuni Chlamydia psittaci, trachomatis Clostridium botulinum, tetani Corynebacterium diphtheriae, Legionella spp, Neisseria gonorrhoeae, Neisseria meningitidis, Pseudomonas pseudomallei, Salmonella spp	Shigella boydii, dysenteriae, flexneri, sonnei Treponema pallidum, Vibrio cholera (including El Tor), Vibrio parahaemolyticus Vibrio vulnificus, Yersinia pestis
Fungal agents	
Blastomyces dermatitidis, Cryptococcus neoformans, Microsporum spp, Exophiala dermatitidis (wangiella)	Fonsecaea pedrosoi, Sporothrix schenckii, Trichophyton spp
Parasitic agents	
Entamoeba, histolytica, Cryptosporidium spp, Giardia spp, Naegleria fowleri, Plasmodium spp	Strongyloides spp, Taenia solium, Toxoplasma spp, Trypanosoma spp

Standard microbiological practices:

- Laboratory doors are kept closed and limited access when experiments are in progress.
- Work surfaces are decontaminated at least once a day and after each spill of viable material.

- All contaminated liquid or solid wastes are decontaminated before being disposed of or otherwise handled.
- Mechanical pipetting devices are used; mouth pipetting is prohibited.
- Eating, drinking, smoking, storing food, and applying cosmetics are not permitted in the work area.
- Wash hands after handling infectious material and animals and when they leave the laboratory.
- All procedures are conducted carefully to minimize the creation of aerosols.
- Laboratory coats, gowns, or uniforms must be worn in the laboratory. Laboratory clothing must not be worn in non-laboratory areas.
- Serological procedures with inactivated antigens known or shown to be free of residual infectivity can be performed on the open bench.

Special practices:

- Contaminated materials that are to be decontaminated at a site away from the laboratory are placed in a durable leak-proof container and closed before being removed from the laboratory.
- The laboratory supervisor limits access to the laboratory when experiments are being conducted. In general, persons who are at increased risk of acquiring infection, or for whom infection may be unusually hazardous are not allowed in the laboratory or animal rooms. Persons at increased risk may include children, pregnant women, and individuals who are immune-deficient or immune-suppressed. The supervisor has the final responsibility for assessing each individual circumstance and determining who may enter or work in the laboratory.
- The laboratory supervisor will assure that only persons who have been advised of the potential hazard and meet any specific entry requirements (e.g. immunization) may enter the laboratory or animal rooms
- When infectious materials or infected animals are present in the laboratory or animal rooms, a hazard warning sign, incorporating the universal biohazard symbol, is posted on all laboratory and animal room access doors and on such other items (i.e. equipment, containers, materials) as appropriate to indicate the presence of viable infectious agents. The hazard warning sign will identify the agent, list the name of the laboratory supervisor other responsible person(s) and indicate any special requirements for entering the area (Immunization, respirators, etc.)
- An insect and rodent control program are in effect.
- Laboratory gowns, coats, gloves, eye protection, or uniforms must be worn in the laboratory but must not be worn to a lunchroom or the laboratory.

- Animals not involved in the experiment being performed are not permitted in the laboratory.
- All wastes from laboratories and animal rooms must be appropriately decontaminated before being disposed of.
- The use of hypodermic needles and syringes is restricted to gavage, parenteral injection and aspiration of fluids from laboratory animals and diaphragm vaccine bottles. Hypodermic needles and syringes are not used as a substitute for automatic pipetting devices in the manipulation of infectious fluids. Serial dilution of infectious agents should not be done in diaphragm bottles with needles and syringes because of the hazards of autoinoculation and of aerosol exposure. Cannulas should be used instead of sharp needles whenever possible.
- If activities of lesser biohazard potential are conducted in the laboratory concur recently with activities requiring BSL-2, all activities will be conducted at BSL-2.
- Gloves will be worn for all procedures requiring the handling of infectious materials or infected animals. Holding small laboratory mammals with forceps when they are receiving injections or otherwise being handled provide an additional level of protection for personnel.
- Serological procedures with inactivated antigens shown to be free of residual infectivity can be performed on the open bench.
- All spills, accidents, and overt or potential exposures to infectious materials must be immediately reported to the laboratory supervisor. A written record must be prepared and maintained. Appropriate medical evaluation surveillance, and treatment must be provided.
- A safety or operations manual that identifies known and potential hazards and specifies practices and procedures to minimize or eliminate such risks should be prepared or adopted by each principal investigator.
- Lab personnel receive appropriate immunizations or tests for agents handled or potentially present in the lab

Containment equipment:

- Biological safety cabinets (Class I, II, III) or other appropriate personal protective or physical containment devices are used whenever:
- Procedures with a high potential for creating aerosols are conducted. These may include centrifugation, grinding, blending, vigorous shaking or mixing, sonic disruption,
- High concentrations or large volumes of infectious agents are use. Such materials may be centrifuged in the open laboratory if sealed heads or centrifuge safety cups are used and if they are opened only in biological safety cabinet.

Laboratory facilities:

- The laboratory should be designed for easy cleaning
- Bench tops should be impervious to water and resistant to acid, alkalis, organic solvents, and moderate heat. The use of plastic-backed absorbent toweling over work surfaces facilitates clean up and minimize aerosols from spills.
- Laboratory furniture should be sturdy, and spaced between benches, cabinets, and equipment should be accessible for cleaning.
- Each laboratory should contain a hand-washing sink, preferably foot or elbow operated.
- If the laboratory has windows that open, they should be fitted with fly screen.
- An autoclave for decontamination of infectious laboratory wastes should be available in the same building with the laboratory.

6.6.3 Biosafety level 3 (BSL-3)

Biosafety Level 3 is suitable for experiments involving agents of high potential risk to personnel and the environment. Laboratory personnel will have specific training in handling pathogenic and potentially lethal agents. They will be supervised by competent scientist(s) who are experienced in working with these agents. Access to the laboratory is controlled by the supervisor. The laboratory has special engineering and design features and physical containment equipment and devices. All procedures involving the manipulation of infectious material are conducted within biological safety cabinets or other physical containment devices or by personnel wearing appropriate personal protective clothing and devices. Examples of BSL-3 agents are included in **Table 6.4**.

Table 6.4. Biohazard agents under BSL-3

Viral agents	
Valley Rift Valley Fever and Zinga virus	VSV exotic strains (Piry) Yellow fever (wild type)
Bacterial / Rickettsial agents	

Bacillus anthracis Francisella tularensis Mycobacterium tuberculosis	Mycobacterium bovis Rickettsia rickettsii Yersinia pestis (resistant strains)
Fungal agents	
Coccidioides immitis	Histoplasma capsulatum

Standard microbiological practices:

- Laboratory doors are kept closed and access limited when experiments are in progress.
- Work surfaces are decontaminated at least once a day and after each spill of viable material.
- All contaminated liquids or solid wastes are decontaminated before being disposed of or otherwise handled.
- Mechanical pipetting devices are used; mouth pipetting is prohibited.
- Eating, drinking, smoking, storing food, and applying cosmetics are not permitted in the work area.
- Persons wash hands when they leave the laboratory and after handling infectious material or animals
- All procedures are conducted carefully to minimize the creation of aerosols.

Special practices:

- Access to the laboratory is controlled by the laboratory supervisor and is restricted to persons whose presence is required for program or support needs. Persons who are at increased risk of acquiring infection or for whom infection may be unusually hazardous are not allowed in the laboratory or animal rooms. Person at increased risk may include children, pregnant women, and individuals who are immune-deficient or immunosuppressed. The supervisor has the final responsibility for assessing each individual circumstance and determining who may enter or work in the laboratory.
- The laboratory supervisor will assure that only persons who have been advised of the potential biohazard, meet any specific entry requirements (e.g. immunization), and comply with all entry and exit procedures may enter the laboratory or animal rooms.
- When infectious materials or infected animals are present in the laboratory or animal rooms, a hazard warning sign, incorporating the universal biohazard symbol, is posted on all laboratory and animal room access doors and on such other items (i.e. equipment, containers, materials) as

appropriate to indicate the presence of viable infectious agents. The hazard warning sign should identify the agent, list the name of the laboratory supervisor or other responsible person(s), and indicate any special conditions of entry into the area (immunizations, respirators, etc.,)

- All activities involving infectious materials are conducted in biological safety cabinets or other physical containment devices. No work in open vessels is conducted on the open bench.
- The work surfaces of biological safety cabinets and other containment equipment are decontaminated when an experiment is finished. The use of plastic-back paper toweling on non-perforated work surfaces within biological safety cabinets facilitates clean up following the completion of activities.
- An insect and rodent control program are in effect.
- Gloves are worn when handling infectious materials or animals. Gloves should be removed aseptically and autoclaved with laboratory wastes before being disposed of.
- Respirators are worn in rooms containing infected animals and when aerosols cannot be safely contained.
- Animals and plants not related to the experiment being conducted are not permitted in the laboratory.
- All laboratory and animal room wastes will be decontaminated before being disposed of or reused.
- Vacuum lines are protected with high efficiency particulate air (HEPA) filters and liquid traps.
- The use of hypodermic needles and syringes is restricted to gavage, parenteral injection, and aspiration of fluids from laboratory animals and diaphragm vaccine bottles. Hypodermic needles and syringes are not used as a substitute for automatic pipetting devices in the manipulation of infectious fluids. Serial dilutions of infectious agents should not be done in diaphragm bottles with needles and syringes because of the hazards of autoinoculation and of aerosol exposure. Cannulas should be used instead of sharp needles whenever possible.
- Syringes that re-sheath the needle, needle-less systems, and other safe devices should be used when appropriate
- If activities of lesser biohazard potential are conducted in the laboratory concurrently with activities requiring BSL-3, all work will be conducted at BSL-3.
- Serologic procedures with inactivated antigens shown to be free of residual infectivity can be performed on the open bench.
- All spills, accidents, and overt or potential exposures to infectious materials must be immediately reported to the laboratory supervisor. A written report must be provided.

- Baseline serum samples should be collected and stored for all laboratory and other at-risk personnel. Additional serum specimens may be collected periodically depending on the agents handled or the function of the laboratory.
- A safety or operations manual, which identifies known and potential hazards and specifies practices and procedures to minimize or eliminate such risks, will be prepared or adopted by each principal investigator. Personnel should be advised of special hazards and must read and follow required practices and procedures.

Biosafety equipment:

6. Biological safety cabinets or other physical containment equipment, or devices, are used for all procedures and manipulation involving infectious material.
7. Activities requiring Biosafety Level 3 physical containment can be conducted in Biosafety Level 2 laboratories if:

    7.4 All standard and special practices specified for the Biosafety Level 3 are followed,

    7.5 All operations and procedures are contained in Class III biological safety cabinets,

    7.6 Materials are only removed from these cabinets through an attached autoclave or in a non-breakable, sealed container, which is passed through an attached disinfectant dunk tank or fumigation chamber.

Laboratory facilities:

- The laboratory is separated from areas, which are open to unrestricted traffic flow within the building. Separation is provided by either a double-door change room and shower or an airlock or other access facility, which requires passage through two sets of doors to enter the laboratory. Access to the laboratory area is designed to prevent entrance of free-living arthropods.
- The surfaces of walls, floors, and ceilings are water resistant and can be easily cleaned. Openings in these surfaces are sealed or capable of being sealed to facilitate decontaminating the area.
- Bench tops are impervious to water and resistant to acids, alkalis, organic solvents, and moderate heat.
- Laboratory furniture is of simple, sturdy construction.
- A foot-or-elbow operated hand-washing sink is provided near each laboratory exit door.
- Windows in the laboratory are closed and sealed.

- Access doors to the laboratory are self-closing and self-locking.
- An autoclave for decontamination of laboratory wastes is available preferably within the laboratory. Infectious wastes, which must be removed to another area in the same building for decontamination, must be held and transported in a covered, leak-proof container.
- An exhaust air ventilation system is provided. This system creates directional airflow that draws air into the laboratory through the entry area. The building exhaust system can be used for this purpose if the exhaust air is not recirculated to any other area of the building. Personnel must verify that proper directional airflow into the laboratory is achieved. However, air within the laboratory can be recirculated. The exhaust air from the laboratory is discharged directly to the outside or through the building exhaust system so that it is dispersed away from occupied buildings and air intakes. The exhaust air from the laboratory that does not come from the biological safety cabinet can be discharged to the outside without being treated.
- In laboratories which have supply air systems, the supply air and exhaust air systems are interlocked to assure inward (or zero) airflow at all times.
- The HEPA filtered exhaust air from Class I or Class II biological safety cabinets is discharged directly to the outside or through the building exhaust system. Air should be recirculated within the laboratory only after it has been filtered through tested and certified cabinet exhaust HEPA filters. Exhaust air from Class III biological safety cabinets must be discharged directly to the outside without being recirculated through the laboratory. If the HEPA filtered exhaust air from Class I or II biological safety cabinets is to be discharged to the outside through a building exhaust air system, it is connected to this system to avoid any interference with the air balance of the cabinet or building exhaust system.

6.6.4 Biosafety level 4 (BSL-4)

Biosafety Level 4 practices, safety equipment, and facility design and construction are applicable for work with dangerous and exotic agents that pose a high individual risk of life-threatening disease, which may be transmitted via the aerosol route and for which there is no available vaccine or therapy. Agents with a close or identical antigenic relationship to Biosafety Level 4 agents also should be handled at this level. When sufficient data are obtained, work with these agents may continue at this level or at a lower level. Viruses such as Marburg or Congo-Crimean hemorrhagic fever are manipulated at Biosafety Level 4.

The primary hazards to personnel working with Biosafety Level 4 agents are respiratory exposure to infectious aerosols, mucous membrane or broken skin exposure to infectious droplets, and autoinoculation. All manipulations of potentially infectious diagnostic materials, isolates, and naturally or experimentally infected animals, pose a high risk of exposure and infection to laboratory personnel, the community, and the environment.

The laboratory worker’s complete isolation from aerosolized infectious materials is accomplished primarily by working in a Class III BSC or in a full-body, air-supplied positive-pressure personnel suit. The Biosafety Level 4 facility itself is generally a separate building or completely isolated zone with complex, specialized

ventilation requirements and waste management systems to prevent release of viable agents to the environment.

The laboratory director is specifically and primarily responsible for the safe operation of the laboratory. His/her knowledge and judgment are critical in assessing risks and appropriately applying these recommendations. The recommended biosafety level represents those conditions under which the agent can ordinarily be safely handled. Special characteristics of the agents used, the training and experience of personnel, and the nature or function of the laboratory may further influence the director in applying these recommendations. Examples of BSL-4 agents are included in **Table 6.5**.

Table 6.5. Biohazard agents under BSL-4.

Viral agents	
Hemorrhagic Fevers (Congo-Crimean, Junín, Machupo) Ebola	Herpesvirus simiae (B virus) Lassa Marburg

6.7. Decontamination

The purpose of decontamination is to make a hazardous material safe for further handling. A decontamination procedure can range from sterilization to simple cleaning with soap and water. There are four main categories of decontamination described below (heating, liquid disinfection, vapors and gases, and radiation) and their effectiveness are summarized in **Table 6.6**.

Table 6.6. Effectiveness of decontaminants

Decontaminant	Active Ingredient/ Conc.	Temp (°C)	Contact time (min)	Vegetative bacteria	Lipo-viruses	Tubercle bacilli	Hydrophilic viruses	Bacterial spores
Autoclave	Steam	121	50–90	+	+	+	+	+
Incinerator	Heat	649-929	1-60	+	+	+	+	+
Phenolic compounds	0.2-3%		10-30	+	+	+	±	–
Chlorine compounds	0.01-5%		10-30	+	+	+	+	±
Alcohol (ethyl or isopropyl)	70-85%		10-30	+	+	+	+	+
Formaldehyde*	4-8%		10-30	+	+	+	+	+
Glutaraldehyde *	2%		10-600	+	+	+	+	±

Hydrogen peroxide	6%		10-600	+	+	+	+	+

+ very positive, ± less positive, - negative, * irritating characteristics of agent precludes use for routine spill cleanup

6.7.1 **Heating**

Wet heat is the most dependable method of sterilization. Steam autoclaving is the most convenient method available for decontaminating biological waste and sterilizing glassware and media. Autoclaves that are used for decontamination of bio-hazardous wastes should be monitored for the efficacy of treatment. This is accomplished by the use of biological indicators (i.e. spore strips).

6.7.2 Liquid disinfection:

Many types of liquid disinfectants are available under a variety of trade names. The most practical use of liquid disinfectants is for surface decontamination. Chemical disinfectants include, but are not limited to, quaternary ammonium compounds, phenolic compounds, halogens, aldehydes, alcohols and amines. A tuberculocidal disinfectant or diluted bleach should always be used for decontamination when human materials are handled.

6.7.3 Vapors and gases:

The use of vapors and gases as decontamination methods usually involve the decontamination of biological safety cabinets, but can also be used for whole building or room decontaminations. Agents used in this category include ethylene oxide, formaldehyde, gas, hydrogen peroxide and peracetic acid.

6.7.4 UV Irradiation:

Ultraviolet (UV) irradiation is sometimes used in biological safety cabinets for inactivating contaminants, but because of the low penetrating power of UV, dusty or soiled areas may limit its usefulness in the laboratory. Because UV can cause serious burns to eyes and skin, it must not be used when work areas are occupied.

6.8. Biosafety Emergency Procedures

Dropping culture flasks and Petri dishes in the open laboratory or containment failure can result in a significant release of aerosols and overt exposure of personnel to bio-hazardous agents. Laboratory personnel should be thoroughly familiar with emergency and decontamination procedures to minimize the extent and possible effects of exposure to hazardous agents.

The following procedures may not be applicable to all laboratories due to the diversity of projects and facilities. The principal investigator is responsible for preparing written emergency procedures for his/her laboratory.

6.8.1 Containment equipment failure

1. Stop work with potentially hazardous material should containment equipment or facility safeguards, such as a biological safety cabinet or building ventilation equipment, fail during an experiment,
2. Notify your supervisor.

6.8.2. Bio-hazardous spills in laboratory

A. Accidents and spills

1. Clear the area at once.
2. Shut down air conditioning or ventilation to area if possible.
3. Notify the laboratory supervisor/director.
4. Assess the type of spill and degree of hazard involved.
5. Determine most effective and least hazardous approach to clean up and decontamination.
6. Determine the necessity for prophylactic treatment or other medical attention for persons exposed to the potentially hazardous materials.

B. "Dry" spills with no significant aerosol formation

1. Evacuation of room probably is not necessary.
2. Flood area with disinfectant solution.
3. Soak up the disinfectant and contaminated material with an absorbent material (sand, kitty litter, commercial type paper towels) and dispose of in a plastic bag or sealed container. Gloves should be worn for cleanup.
4. Autoclave the contaminated material.

C. Liquid spills on bench or floor

1. If significant aerosols were formed the area should be evacuated and not reentered for at least an hour.
2. Cover the spill with an absorbent (sand, kitty litter, paper towels). Gloves should be worn during cleanup.
3. Dispose of the absorbent and contaminated materials in plastic bags or sealed container and autoclave.

D. Centrifuge accidents

1. Shut off instrument, evacuate area at once, and shut down ventilation to area.
2. Do not enter area for at least one hour or until aerosols have settled.
3. The person entering the area to clean up will wear protective clothing, gloves, and mask.

4. Soak up liquids in absorbent material and handle as above. If not a liquid, clean the instrument and clean the room thoroughly before resuming work.

E. Spills in incubators, autoclaves, or other closed areas.

1. Soak up liquids with an absorbent and dispose of as outlined in B-3 and B-4.
2. The unit may need decontaminating by means of a sterilizing gas such as formaldehyde or glutaraldehyde and left overnight if routine cleanup is not possible.
3. The unit should be thoroughly washed (if possible) after decontamination

6.8.3 Spill decontamination

1. Wait 30-60 minutes to allow dissipation of aerosols created by the spill.
2. A "Spill Kit" should be available and should include leak-proof containers and autoclavable bags, forceps, paper towels, sponges, disinfectant, respirators, and rubber gloves. A UV lamp may be helpful in emergency situations.
3. Wear protective clothing when entering the laboratory to clean the spill area such as rubber gloves, autoclavable footwear, an outer garment, and a respirator. Do not wear a gown that may trail the floor when bending down for spills on the floor
4. Pour a germicidal solution (10% Wescodyne in 50% ethanol or 5% Hypochlorite are recommended) around the spill and allow to flow into the spill. Paper towels soaked with germicide may be used to cover the area. To minimize re- aerosolization, avoid pouring the germicidal solution directly onto the spill.
5. Let stand 20 minutes to allow adequate disinfectant contact time.
6. Transfer contaminated materials (paper towels, glass, liquid, gloves, etc.) into a deep autoclave pan using an autoclavable dust pan and squeegee. Cover the pan with aluminum foil or other suitable cover and autoclave according to standard directions.
7. The dust pan and squeegee should be placed in an autoclavable bag and autoclaved according to standard directions.
8. Remove protective clothing and sterilize by autoclaving.

6.8.4 Spill in a class II cabinet

1. Notify the supervisor if a splash occurs outside the cabinet resulting in personnel exposure to hazardous material.
2. Remove contaminated clothing and containerize it for autoclaving.
3. Thoroughly wash hands and face if exposure has occurred.
4. Initiate chemical decontamination procedure at once while the cabinet continues to operate to prevent escape of contaminants from the cabinet.

5. The operator will wear gloves and laboratory coat during this procedure.
6. Spray or wipe walls, work surface, and equipment with an appropriate disinfectant detergent.
7. Dump excess disinfectant from tray and drain pans into cabinet base.
8. Discard gloves, cloth or sponge in an autoclave pan and autoclave.
9. Drain disinfectant from cabinet base into an appropriate container and autoclave according to standard procedures.
10. This procedure does not decontaminate the interior parts of the cabinet such as the filters, blowers, and air ducts.

6.8.5 Spill involving blood or body fluids

1. Wear disposable gloves
2. Absorb fluids with disposable towels
3. Clean area of all visible fluids with detergent (soap/water),
4. Decontaminate area with a 1:10 dilution of bleach: water if surface is porous, 1: 100 if surface is hard, smooth
5. Place all disposable materials into a plastic leak-proof bag

Spills involving concentrated microorganisms requiring biosafety level (BL2) containment (E. Coli, Staphylococcus, adenoviruses, etc.)

1. Alert people in immediate area of spill
2. Put on protective equipment
3. Cover spill with paper towel or other absorbent materials
4. Carefully pour a freshly prepared 1:10 dilution of household bleach around the edges of the spill and then into the spill.
5. Avoid splashing
6. Allow a 20-minute contact period Use paper towels to wipe up the spill, working from the outer edges into the center
7. Clean spill area with fresh towels soaked in disinfectant

8. Place towels in a plastic bag and decontaminate in an autoclave.

Spills involving concentrated microorganisms require (BL3) containment (Mycobacterium Tuberculosis, (TB) cultures)

Attend to injured or contaminated persons and remove them from exposure

1. Alert people in the area to evacuate
2. Close doors to affected area; do not enter area for at least one hour
3. Have a person knowledgeable of the incident and area assist in proper clean up
4. Wearing gowns, gloves, respirator and shoe covers, clean up spills as indicated for Biosafety Level 2 organisms.

6.8.6 Reporting Laboratory Accidents

Report, in writing, to your Lab Engineer/Technician all laboratory accidents that result in exposure of laboratory personnel. Such exposures include inoculation through cutaneous penetration, ingestion, probable inhalation following gross aerosolization, or any incident causing serious exposure to personnel or danger of environmental contamination. The following information must be in the report

1. Exposed personnel: Name, age, sex, occupation, and department.
2. Date, time, and place of exposure.
3. Type of accident (accidental injection with a needle, contaminated aerosol, animal bite, etc.)
4. Description of incident (specify hazardous agents)
5. Medical attention provided.

6.9. Control of Exposure to Blood-borne Pathogens

6.9.1 Exposure minimization

The Occupational Safety and Health Administration (OSHA) of the USA promulgated a standard to minimize the risk for occupational exposure to blood-borne pathogens (e.g., HIV, Hepatitis B). The regulation titled Occupational Exposure to Blood-borne Pathogens mandates several provisions for those working with human derived blood, blood products, other bodily fluids and any unfixed issues. Relative to this, OSHA enacted the Blood-borne Pathogen Standard, 29CFR1910.1030 to reduce occupational exposure to Hepatitis B virus (HBV), Human Immunodeficiency Virus(HIV), and other blood-borne pathogens that employees may come in contact with in the workplace. There are a number of principles to follow when working with infectious material or responding to medical emergencies.

- Minimize all exposure to all pathogenic organisms
- Do not underestimate the risk of exposure to pathogenic agents.

- Use as many engineering and work practices as possible to minimize exposure
- As provided in 29CFR 1910.1030 occupational exposure means reasonably anticipated skin, eye, mucous membrane or parenteral contact with blood or other potentially infectious materials that may result from the performance of an employee's duty. Potentially infectious materials include:
    1. Body secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, amniotic fluid that is visibly contaminated with blood and all body fluids in situations where it is difficult or impossible to differentiate between body fluids.
    2. Any unfixed tissue or organ (other than intact skin) from a human (living or dead).
    3. HIV/HBV-containing cell or tissue cultures, organ cultures and HIV or HBV-containing medium or other solution: and blood, organs or other tissues from experimental animal infected with HIV or HBV.
    4. Other pathogens that are transmitted by ingestion or inhalation.

There are a number of areas that must be addressed in order to effectively eliminate or minimize exposure to blood-borne pathogens. The first five areas are discussed below. By following the requirements of OSHA's Blood-borne Pathogens Standard in these five areas, the employees' occupational exposure to blood borne pathogens will be eliminated or substantially minimized.

6.9.2 Universal precautions

- All human blood and body fluids are treated as if they are known to be infectious for blood-borne or other pathogens.
- Animal blood, fluids, and material and other human materials (i.e. feces, urine, etc.) are handled as infectious materials.
- In circumstances where it is difficult or impossible to differentiate between body fluid types, the assumption should be made that all body fluids to be potentially infectious.

6.9.3 Engineering controls

- Hand-washing facilities (or antiseptic hand cleansers and towel), should be readily accessible to all employees who have the potential for exposure.
- Containers for contaminated sharps should be:
    1. Puncture-resistant
    2. Color-coded or labeled with a biohazard warning label
    3. Leak-proof on the sides and bottom
    4. Closable

- Specimen containers should be:
    1. Leak-proof
    2. Color-coded or labeled with a biohazard warning label
    3. Puncture-resistant, when necessary
    4. Closeable
- Secondary containers should be:
    1. Leak-proof
    2. Color-coded or labeled with a biohazard warning label
    3. Puncture-resistant, if necessary

6.9.4 Work practice controls

- Employees wash their hands immediately, or as soon as possible, after removal of gloves or other personal protective equipment.
- Following any contact of body areas with blood or any other infectious materials, employees wash their hands and any other exposed mucous membranes with water.
- Contaminated needles and other contaminated sharps are not bent, recapped or removed unless:
    1. It can be demonstrated that there is no feasible alternative
    2. The action is required by specific medical procedure
    3. In the two situations above the recapping or needle removal is accomplished through the use of a mechanical device or a one- handed technique
- Contaminated reusable sharps are placed in appropriate containers immediately, or as soon as possible, after use.
- Eating, drinking, smoking, applying cosmetics or lip balm and handling contact lenses is prohibited in work areas where there is potential for exposure to blood-borne pathogens.
- Food and drink are not kept in refrigerators, freezers, on countertops or in other storage areas where blood or other potentially infectious materials are present.
- Mouth pipetting/suctioning of blood or other infectious materials is prohibited.
- All procedures involving blood or other infectious materials should be conducted to minimized splashing, spraying or other actions generating droplets of these materials.

- Specimens of blood or other materials are placed in designated leak-proof containers, appropriately labeled for handling and storage.
- If outside contamination of a primary specimen container occurs, that container is placed within a second leak-proof container, appropriately labeled, for handling and storage.
- Equipment that becomes contaminated is examined prior to servicing or shipping, and decontaminated as necessary
- An appropriate biohazard-warning label is attached to any contaminated equipment, identifying the contaminated portions. Information regarding the remaining contamination is conveyed to all affected employees, the equipment manufacturer and the equipment service representative prior to handling, servicing or shipping.

6.9.5 Personal protective equipment

Personal protective equipment (PPE) is the main line of defense against blood-borne pathogens. This equipment includes, but not limited to:

- Gloves
- Gowns
- Laboratory coats
- Face shields/masks
- Safety glasses
- Mouthpieces
- Resuscitation bags
- Pocket masks
- Hoods
- Shoe covers

Use the following practices to ensure that PPE is not contaminated and is in the appropriate condition to protect employees from potential exposure,

- Inspect all PPE periodically and repair or replace as needed to maintain its effectiveness
- Clean reusable PPE, launder and decontaminate as needed

Adhere to the following practices when using their PPE:

- Remove immediately any garments penetrated by blood or other infectious materials
- Remove all PPE prior to leaving the work area
- Wear gloves in the following circumstances:
    1. Whenever employees anticipate hand contact with potentially infectious materials
    2. When performing vascular access procedures
    3. When handling or touching contaminated items or surfaces.
- Disposable gloves are replaced as soon as practical after contamination or if they are torn, punctured or otherwise lose their ability to function as an "exposure barrier."
- Utility gloves are decontaminated for reuse unless they are cracked, peeling, torn, or exhibit other signs of deterioration, at which time they are disposed.
- Masks and eye protection are used whenever splashes or sprays may generate droplets of infectious materials
- Protective clothing is worn whenever potential exposure to the body is anticipated
- Surgical caps/hoods or shoe covers/boots are used in many instance where "gross contamination " anticipated.

6.9.6 Housekeeping

- Clean and decontaminate all equipment and surfaces contaminated with blood or other potentially infectious materials:
    1. Immediately when surfaces are contaminated
    2. After any spill of blood or infectious materials
    3. At the end of the work shift if the surface may have been contaminated during that shift
- Protective coverings are removed and replaced:
    1. as soon as feasible when overtly contaminated
    2. at the end of the work shift if they may have been contaminated during the shift
- All pails, bins, cans , and other receptacles intended for use routinely are inspected, cleaned, and decontaminated as soon as possible if visibly contaminated.
- Potentially contaminated broken glassware is picked up with mechanical means (dustpan and brush)
- Contaminated reusable sharps are stored in containers that do not require "hand processing."

- All types of infectious wastes are discarded or "bagged" in containers that are:
    1. closable
    2. puncture-resistant
    3. leak-proof if the potential for fluid spill or leakage exists.
    4. red or labeled with the biohazard warning label
- Containers for regulated waste are located throughout within easy access to employees and as close as possible to source of waste.
- Waste containers are maintained upright, routinely replaced and not allowed to overfill
- Contaminated laundry is handled as little as possible and is not sorted or rinsed where it is used.
- Whenever employees move containers of regulated waste from one area to another, the containers are immediately closed and placed inside an appropriate secondary container if leakage is possible from the first container.

6.9.7 Vaccination Program

Employees who may have an occupational exposure to blood borne pathogens should have a vaccination program for Hepatitis B Virus. The vaccination program should consist of a series of three inoculations over a six-month period.

6.9.8 Incident reporting post exposure evaluation and follow up

If an employee is involved in an incident where exposure to blood-borne or other highly infectious pathogens may have occurred, efforts should be focuses on getting medical consultation and treatment expeditiously. The following procedure should be followed:

- Report the incident to supervisor
- Supervisor with employee complete "Accident/Illness Form"
- Supervisor refers employee copy of Accident/Illness form to Environmental Health and Safety

A confidential medical evaluation and follow-up will be conducted by a qualified healthcare professional at no charge to the employee. Follow-up may include vaccination, blood testing, and counseling.

The employee's supervisor will investigate the circumstances surrounding the incident to determine what action (training, change in work practice, engineering controls) can be taken to prevent similar incidents in the future.

6.9.9 Labels and Signs

Labels or color-coding is required for:

- Containers of regulated waste
- Refrigerators/freezers containing blood or other potentially infectious materials
- Sharps disposal containers
- Other containers used to store, transport, or ship blood and other infectious materials
- Laundry bags and containers
- Contaminated equipment
- Biohazard signs must be posted at entrances to HIV and HBV research laboratory facilities.

6.9.10 Training

Employees who have the potential for exposure to blood-borne or other pathogens should receive a comprehensive training program. Employees should receive initial training and have training at least annually to keep their knowledge current. All new employees, as well as employees changing jobs or job functions, should be given any additional training their new position requires prior to beginning their new job assignments. The topics covered in the training program include, but are not limited to the following:

- The Blood-borne Pathogen Standard.
- The epidemiology and symptoms of blood-borne and other disease.
- The modes of transmission of blood-borne and other pathogens.
- The department's Exposure Control Plan.
- Appropriate methods for recognizing tasks and other activities that may involve exposure to blood and other potentially infectious materials.
- A review of the use and limitations of methods that will prevent or reduce exposure, including:
    - Engineering controls
    - Work practice controls
    - Personnel protective equipment
    - Selection and use of personal protective equipment including: types available, proper use, location, removal, handling, decontamination, and disposal.
- Visual warning of biohazards including labels, signs, and "color-coded" containers
- Information on the Hepatitis B Vaccine, including its: efficacy, safety, method of administration, benefits of vaccination, and the vaccination program.

- Actions to take and persons to contact in an emergency involving blood or other potentially infectious materials
- The procedures to follow if an exposure incident occurs, including incident reporting
- Information on post-exposure evaluation and follow-up including medical consultation

6.9.11 Record keeping

Employee training records should be maintained in the Department and/or College. The training record should contain the following information:

- Dates of all training sessions.
- Contents/summary of the training sessions.
- Names and qualifications of the instructors, lab engineers and technicians.
- Names and job titles of employees attending the training sessions.

6.10 Biohazard Wastes

6.10.1 Infection wastes

- Cultures and stocks of infectious agents and associated biologicals;
- Human blood and blood products,
- Pathological wastes,
- Contaminated sharps,
- Contaminated animal carcasses, body parts, and bedding,
- Wastes from surgery, necropsy and other medical procedures,
- Laboratory wastes,
- Isolation wastes, unless determined to be non-infectious by the infection control committee at the health care facility,
- Any other material and contaminated equipment which, in the determination of the facility infection control staff, presents a significant danger of infection because it is contaminated with, or may reasonably be expected to be contaminated with, etiologic agents.

6.10.2 Chemical wastes

Chemical Wastes subject to the requirements of biohazard waste regulations include wastes from the following categories:

- Pharmaceutical wastes,
- Laboratory reagents contaminated with infectious body fluids,

- All the disposable materials which have come into contact with cytotoxic/antineoplastic agents during the preparation, handling, and administration of such agents, and
- Other chemicals that may be contaminated by infectious agents, as designated by experts at the point of generation of the waste.

6.10.3 Sharps

Sharps are used in animal or human patient care or treatment or in medical research, or industrial laboratories, including: hypodermic needles, syringes, (with or without the attached needle), Pasteur pipettes, scalpel blades, suture needles, blood vials, needles with attached tubing, and culture dishes (regardless of presence of infectious agents). Also included are other types of broken or unbroken glassware that were in contact with infectious agents, such as used slides and cover slips.

6.10.4 Guidelines for disposal

- Untreated biohazard waste shall never be disposed of in the municipal solid waste stream.
- Prior to any treatment, all biohazard wastes- including those to be incinerated- shall be enclosed in a puncture-proof, red biohazard bag that is marked with the universal biological hazard symbol.
- All sharps intended for disposal, whether contaminated or not, shall be enclosed in sharps containers. Recapping needles is dangerous and shall be avoided. Treat syringes as you would a controlled substance. It is recommended that all unwanted syringes be destroyed after disinfection but before disposal in the solid waste stream. Destroying an infectious sharp or syringe before disinfection could spread contamination. Special consideration should also be given to the disposal of contaminated pipettes.
- After disinfection but before disposal in the municipal waste stream, all treated biohazard wastes shall be enclosed in an unmarked outer bag that is not red.
- Biomedical wastes that are also radioactive should be treated according to requirements for both biomedical and radioactive waste.

6.10.5 Treated biohazard wastes

Treated Biohazard Wastes are all biohazard wastes that have been treated by one of the following methods and rendered harmless and biologically inert:

- Incineration in an approved incinerator,
- Steam sterilization at sufficient time and temperature to destroy infectious agents in waste ("autoclaved"),
- Chemical disinfection where contact time, concentration, and quantity of the chemical disinfectant are sufficient to destroy infectious agents in the waste.

7

MECHANICAL SAFETY

7 MECHANICAL SAFETY

Within all laboratories as well as the Mechanical Workshop at the college of engineering there are various hazards from rotating machinery, grind wheels, hand-held drilling machines, saws and cutting tools, guillotine, bending and punching tools etc.

The prime rule of safety within a mechanical workshop as well as with other labs is that of good housekeeping and general tidiness. In addition, students are not permitted entrance to the mechanical workshop and labs unless approval has been obtained from the lab engineer or technician.

The tools and equipment are for student use in building approved projects or conducting class experiments. Safe operation is important to insure successful project or experiment completion, but most importantly to insure the personal safety of the operator and those observing. The following will help to insure the safe operation and avoid injury.

7.1 General safe working procedure

- Only use tools and machines for their intended purpose.
- Report all damaged equipment and do not use it until a qualified person has repaired it.
- Do not operate a machine if you are wearing loose clothing – button up shirtsleeves or overalls.
- Where machine guards are provided, they must be kept in place.
- Long hair needs to be restrained by either a tie or hat.
- Always use clamps to hold a work piece in the drilling machine table. Do not attempt to hold the work piece by hand. Brass is particularly liable to seize on the drill bit unless the correct type of bit is used and the bit kept sharp. Get advice from trained technical staff if you are at any time unsure. *Do not take risks*. Return all drill bits to their proper holder.
- Do not use hand tools of the wrong size and ensure that the hand tool (whether spanner or screwdriver etc.) fits the work correctly.
- Never use hand files unless they have a proper handle fitted. The pointed tang of a file can slip and pierce the palm of the hand.
- Ensure that hand-cutting tools are sharp – a blunt hand tool will slip easily and can cause injury. When using a hand tool remember to apply the force for cutting or filing in a direction *away* from the body.
- Keep machine tools, workbenches and surrounding areas clean of loose metal sward and chippings.
- If the machining operation requires you to do so, (e.g. drilling, grinding a tool) always use safety glasses as well as the machine guard.

- Abrasive grind wheels can cause serious eye injuries due to grit being thrown from the grind wheel – wear appropriate eye protection. Grinding wheels are subject to additional legislation and must only be mounted and adjusted by a trained workshop technician.
- Never use compressed air for cleaning clothing and machinery.
- Only one person will operate a machine at any one time.
- Ensure the safety of yourself and others by being aware of your surroundings. If you see someone committing an unsafe act, report it to the supervisor immediately. As the machine operator you are responsible for the safety of the people in your immediate area. It is your responsibility to look around and be sure that everyone within your range is wearing safety glasses. Likewise, a welder must be sure not to start welding if people without welding helmets are watching him.
- Use hoisting and lifting equipment held in the college when moving heavy weights around. Make sure that slings are correctly placed. If you are unsure, ask and do not take risks.
- Always ensure that when you leave a machine or piece of equipment that it is in a safe condition for the next person to approach and use.
- You may not wear gloves while operating machinery. Holding objects with a rag near moving machinery is also not permitted. Gloves, rags, etc. can be easily caught in machines that are in motion, pulling the operator into the equipment.
- Machinery may not be left running unattended. You must be at the controls of the machine you are using whenever it is in motion.
- Observers must not distract the operator of a machine as this may cause serious injury to the operator or the observers.
- Observe the limitations of all machines.

NOTE 1: If you are in doubt about the operating procedures of any piece of mechanical equipment, find out before you switch it on, or attempt to use it, otherwise damage may be caused to the equipment or injury to yourself or some other person who may happen to be in the vicinity at that time.

NOTE 2:It is the responsibility of the officer in charge of the workshop to ensure that staff who use the workshop only occasionally adopt the same safety precautions and procedures as full-time workshop personnel.

7.2 Hand Tools

Hand tools are non-powered. They include anything from axes to wrenches. The greatest hazards posed by hand tools result from misuse and improper maintenance.

- Hammers or mallets with broken handles or loose heads should not be used.
- Mushroom heads on chisels and punches should be "dressed" properly or the tool should be discarded.
- While chipping, use prescribed type of goggles and chip in a direction where flying chips can do no harm. Use a screen if necessary.
- When cutting with pliers, be sure cuttings do not fly.
- A wood saw or hacksaw should be started by drawing the saw blade backward if fingers are used to guide it at the cutting edge.
- All files should be equipped with handles.
- Use wrenches properly sized for the job. Be sure wrench jaws are not sprung, chipped, or have worn teeth. Never use a wrench as a hammer.
- Clean grease and oil from hands before using tools to prevent slipping
- To prevent injury or damage to your project use only tools that are in good condition.
- Use tools only for the job that they were designed for. Screwdrivers are for turning screws; hammers are for striking objects; parallel bars are for holding material in place until clamped; etc.
- A chisel or punch head that becomes mushroomed should be given to the supervisor for repair. Mushroomed heads can chip off and cause injuries.
- Cut away from your hands and body when using a knife or sharp object.
- Use a wrench on nuts and bolts, not pliers.
- Use open-end or adjustable wrenches that fit the nut snugly to prevent slipping and injuring fingers or damaging parts.
- Use the correct size tool for the job. That includes screwdrivers.
- All power tools must be turned off and have come to a complete stop before the operator can set them down. NO EXCEPTIONS.

7.3 Machine Tools

- Stand to one side-never directly in line-with work being fed through machines such as circular saws, jointers, or wood shapers.
- Revolving shafts, although apparently smooth, will catch loose or ragged clothing, gloves, jewelry, hair, or wiping rags. Proper clothes and caution are always necessary when working around any revolving machinery. Shirtsleeves should be rolled up. Neckties should not be worn.

- Goggles must be worn whenever flying chips, particles of material, liquids, chemicals, or sparks may cause eye injury.
- Whenever possible, ground all power tools.
- Machinery should be inspected regularly to insure cleanliness and proper operation.
- Machinery should be placed and anchored securely to prevent tipping or other movement.
- There should be a power shut-off switch within reach of the operator at each machine.
- Machinery should be equipped with an emergency stop button that is colored red.
- Manually operated valves and switches controlling the operation of machines should be identified and readily accessible.
- Machines must be shut down before cleaning, repairing, or oiling. Disconnect or use Lock Out techniques.
- Keys or adjusting tools must never be left so that they may creep, be thrown, or fall when a machine is started.
- When drilling or tapping material sees that it is securely fastened by blocks or clamps so that it cannot spin or climb the drill. In no case should the operator rely on his hands to secure the material from turning.
- Use a brush, special tool, or hook to remove chips, shavings, or other material from work.
- Transparent guards should be kept clean.
- Keep fingers clear of a machine's point-of-operation by using special tools or devices, such as push sticks, hooks, or pliers.

7.3.1 Drill press

- Check the drill press head and table for security and condition before starting.
- A center punch will help locate the hole to be drilled in the correct place.
- Clamp material to be drilled securely to the drill-table before starting the machine.
- Tighten the chuck of the drill press and remove the release key before starting the machine or your arm may be twisted around the spindle. Never leave the key in the chuck.
- Use drills properly sharpened to cut the right size.
- Run drills only at the correct speed and do not force or feed too fast. Broken drills can cause serious injury.

- If your work should slip from the clamp, never attempt to stop it with your hands. Stop machine to make any adjustment or repair.
- Drill presses should never be forced by exerting excess pressure on the feed lever.
- Drive belts should be covered.
- Hands are to be kept clear of the revolving spindle, chuck, drill and chips.
- Drilling soft materials such as brass, cooper, or plastic is done with a drill ground differently than drills used for steel.
- When drilling large holes drill a pilot hole with a small drill such as 1/8 and then step up in size to prevent drill chatter.
- Be sure the drill press is stopped before removing the work piece, chips or cuttings.

7.3.2 Electric drill (hand held)

- Center punch the hole to be drilled.
- Tighten the drill using the chuck key and remove the chuck key immediately.
- Hold the drill motor firmly, and keep hands away from the revolving spindle and drill.
- Use a larger drill if a larger hole is needed. Using side pressure on the drill to "wobble" out the hole to increase the diameter will only damage the drill and cause it to break.
- Apply straight and steady pressure on the drill, and ease up on the pressure as the drill begins to break through the material.
- With the motor still running back out the drill as soon as the hole is drilled.
- Turn off the drill and hold firmly until it comes to a complete stop before laying it on the workbench.

7.3.3 Bench Grinder

- Adjust the work rest to within 1/16 inch of the wheel face.
- Stand to the side of the grinder, not in line with the wheels, turning on a grinder and while the wheels are accelerating, this is the most common time for a damaged wheel to fly apart.
- Do not allow hands to come in contact with the grinding wheel while it is in motion.
- Dress the grinding wheel when it is worn uneven or out or round.
- Hold the work firmly, and make grinding contact without bumping or impacting the grinder.
- Use only enough pressure to assure grinding, but not heavy pressure, as this will only cause overheating and grinder damage. If the work piece begins to get warm, quench it in water.
- Grind only on the face of the wheel. Grinding on the side can cause the grinder wheel to explode due to heat stress buildup.
- Keep the work piece in motion across the face of the wheel.

- Stone type grinding wheels are not for grinding aluminum, brass, or copper because the soft metal becomes imbedded in the stone, overheats, and can explode.

7.3.4 Friction saw

- The work piece must be securely clamped. NO EXCEPTIONS
- The friction saw, like the grinder, is for steel only. Aluminum and other soft metals will build up on the blade and cause it to overheat and explode.

7.3.5 Disc grinder – Portable

- You must wear a face shield as well as safety glasses when using the disc grinder.
- Always be aware of the direction you are throwing the stream of sparks. It is your responsibility to be sure you are not throwing them on other people, in the vicinity of those without eye protection, or on potentially flammable items.
- Like all other hand tools, the disc grinder must be stopped (not moving) before it can be set down.

7.3.6 Buffer (wire or cloth)

- Hold the work piece firmly with both hands.
- Keep hands away from the buffer while it is in motion.
- Hold the work piece below center (horizontal axis) of the wheel.
- Apply buffing compound sparingly to cloth buffers.
- Using excessive pressure will cause the work piece to overheat and damage the surface.

7.3.7 Engine hoist

- NEVER work under anything hanging from a crane, or on a jack. Use jack stands capable of supporting the amount of weight necessary.
- You must ask the lab engineer or technician for permission to use the engine hoist.

7.3.8 Band saw – Vertical

- Use only the correct blade for the material being cut. (Fine blade for steel, coarser one for aluminum)
- CAUTION: Stand to one side while doing power-on testing of blade tracking. Should the blade come off the wheels or break it could cause serious injury.
- Adjust the blade guides and rollers properly, and adjust the speed. The upper saw guide should be 1/4 inch or less above the work piece.
- Check the work piece to be sure it is free of defects (i.e. broken off tool bits, etc.)
- Plan the cut so as to prevent backing out of a cut, as this will pull the blade off the wheels. Make relief cuts as needed.

- Holding the work piece firmly, feed the work piece at a moderate rate.
- Use a push stick when sawing small pieces.
- When feeding a work piece into the band saw blade your fingers should not be in line with the blade in case the work piece cuts faster than you expected.
- A minimum of three teeth must be engaged in the work piece at all times or the teeth will be torn off of the blade.

7.3.9 Band saw – Horizontal

- All work pieces must be secured in the machine's clamp.
- The moveable jaw of the machine's clamp pivots about its center. Thus, if your work piece extends less than half way through the jaws of the clamp, you must use a spacer on the other side of the pivot in order to prevent slipping.
- Do not allow the machine to drop rapidly causing the blade to impact the work piece. Slowly lower the saw and let it gently engage the work piece.
- A minimum of three saw teeth must be engaged in the work piece at all times. If fewer teeth are engaged then the force per tooth is so great that the teeth will tear off the blade.
- Control the decent of the blade through the entire cut, do not allow it cut through the material as fast as it can possible go.
- The horizontal band saw is a flood coolant machine; the fluid that flows over the blade is recirculated. If the fluid is not flowing then inform the supervisor immediately and it will be refilled.

7.3.10 Engine lathe

- Make sure that all gear and belt guards are in place.
- Never leave a chuck wrench in a chuck.
- Keep your hands-off chuck rims when a lathe is in operation.
- Do not attempt to screw the chuck onto the lathe spindle with the power on, as it may get cross-threaded and cause injury. Stop the machine, place a board under the chuck, and then screw on by hand.
- Steady rests should be properly adjusted to conform with the material being worked on.
- When filing work in a lathe, file with the right hand over lathe instead of left hand, and face the headstock. If left-handed, reverse lathe and file from back side of lathe.
- See that tailstock, tool holder, and work are properly clamped before turning on power.
- Never attempt to adjust a tool while the lathe is running.
- Never apply a wrench to revolving work or parts.
- Always use a brush to remove chips–never your hands.

- When possible, use pipe sleeves to cover work protruding from the end of the lathe.
- Before removing your work from the lathe, remove the tool bit.
- Roll up loose sleeves, and do not wear loose clothes such as sweaters or neckties while operating the lathe
- Be certain the work piece is set up securely and tightly when using chucks and collets.
- Keep hands away from chips as they are very sharp and possibly hot.
- Complete cuts that are close to the chuck or against a shoulder by hand feeding to prevent machinery or work piece damage.
- Remove the tool holder and tool post before filing or polishing.
- Never move the speed selector controls while the spindle is rotating.
- Never push the reverse switch while a chuck is moving forward as this could cause the chuck to unscrew itself and fall off and cause serious injury.
- Regulate the depth of cut according to the size and type of material.
- Use tools that are properly ground for the particular job.
- You may never check measurements or surface finishes of the work piece while it is spinning.
- After you have chucked up your work piece and completed your tool setup you must spin the chuck by hand to ensure that the jaws of the chuck and the work piece will not hit the carriage of the lathe or the tool rest. Between Centers Turning.
- Use the safety dog to drive work piece.
- Use only a live center Chuck and Faceplate Turning.
- Counterbalance work piece on the faceplate if it is irregular in shape.
- Stand to one side of the revolving faceplate to avoid being hit by flying objects.

7.3.11 Milling machine

- Secure the work piece firmly in the vice or with appropriate clamps.
- Check the work piece, milling machine table, and holding device for clearance of the quill during the cutting.
- Set the machine for the proper depth of cut.
- Select the correct spindle speed for the type of material and the cutter being used.
- Select the proper direction of rotation for the cutter.
- Feed the work piece against or opposite the direction of rotation of the cutter.

- Keep hands on the controls while the machine is running.
- Never try to feel the finished surface while the cut is being taken.
- The milling machine is a precision piece of equipment so it is important to not damage the table. The table is not a workbench or a place to put tools.
- Be sure you know how to stop the milling machine quickly before operating the machine.
- Be sure the power feed controls are in their "Neutral" position before turning on the machine.
- Handle cutters carefully. They are sharp. If they can cut metal, they can cut you.
- Use a soft hammer or mallet to seat the work piece against the parallel bars or bottom of the vice.

7.4 Oxygen (Acetylene Welding)

- Signs reading "DANGER–NO SMOKING, MATCHES, OR OPEN FLAMES" or the equivalent should be posted.
- Grounding of the machine frame and safety ground connections of portable machines should be checked periodically.
- Electrical power to the welder should be shut off when no one is present.
- Welding is to be done only by those employees who are qualified as welders.
- Always stand to one side and away from the gauge faces and front of the regulator when opening the cylinder valve. In case of an explosion, flying glass will not cut you.
- Oxygen is not a substitute for compressed air. Never use oxygen equipment around oily gloves, clothes or oily surfaces. Oil or grease in presence of oxygen, under pressure, will ignite violently.
- Suitable fire extinguishing equipment should be available for instant use.
- Firewatchers should be assigned when welding or cutting is performed in locations where a serious fire might develop.
- Cylinders have exploded from what seemed to be slight jars. Be sure your cylinders are chained or strapped securely.
- Never use acetylene from a cylinder in a horizontal position. In this position, the acetone is drawn out of the cylinder with the acetylene.
- Use the cylinder valve–not the regulator–to turn the gas off. The regulator is not designed to be used as a shut-off valve.
- Do not watch the electric arc without welding lenses. Ultra- violet and infrared rays are thrown off in concentrated form and can burn unprotected eyes.
- Local exhaust ventilation is recommended for most welding, cutting, and brazing. It is required when the following base metals, fluxes, coatings, platings, or filler metals are used: Beryllium;

Cadmium; Chromium; Fluorides; Lead; Mercury; Zinc; Inert gas welding; Oxygen cutting of stainless steel.

- Cylinders must always be fastened with a chain or other suitable device as a protection against falling or rolling.
- Keep the welding equipment free of oil and grease, and away from oily rags. When oil comes in contact with oxygen it will explode.
- If leaks are detected in the equipment, they are to be reported immediately to lab engineer or technician.
- Adequate ventilation is needed in the welding area before beginning.
- Keep ALL flammable material away from the work area.
- Never open an acetylene cylinder valve more than one-half (1/2) turn. Always keep the key on the acetylene cylinder valve. In case of a flashback or fire from a leaky cylinder connection, a gloved hand can withstand the heat long enough to close the valve.
- Eye protection helmets, hand shields, and goggles meeting the appropriate standards are required.
- Release the regulator pressure screw and open the cylinders slowly.
- The normal pressure setting for acetylene is 5 psi with a maximum of 15 psi.
- The oxygen cylinder valve should be opened all the way as it is a double seating valve.
- The normal pressure setting for oxygen is 10 psi with higher settings used for torch cutting.
- Point the torch away from yourself and observers before lighting the torch.
- Use a friction torch lighter (flint striker) to ignite the torch.
- A lighted torch should not be turned on concrete. Concrete always contains some moisture, which may cause the concrete to explode.
- Close the acetylene valve first if the torch backfires.
- Keep sparks and flames away from the gas cylinders and hoses.
- Close both cylinder valves and then release the pressure from the lines when you have finished the job.
- Hot metals are to be quenched rather than left lying on the table hot, or mark with chalk the word “HOT’ if air cooling is desired.
- Clean your work area when completed and put scrap metals in the appropriate container.

7.5 Electri`c Welding

- A proper welding helmet, long sleeves or leather apron, long pants and leather gloves (or cotton gloves if TIG welding) are required to protect the welder and observers from eye and skin damage due to the intense ultraviolet (UV) radiation that emanates from the arc.
- Do all welding in the welding area if at all possible. Shields and fire hazard precautions will need special attention if welding in other areas.
- Check for adequate ventilation before welding.
- Welding on zinc-plated metals is hazardous to your health, and can be fatal. Do not weld on zinc-plated metal (galvanized metal).
- For assistance in setting up the welding equipment ask the supervisor.

- After your weld is complete, quench the work piece in water.
- Before you begin welding, you must set up the welding shields to protect others from the effects of the UV radiation on their eyes and skin.

7.6 Spot Welding

- Open the water coolant valve to maintain a slow water flow.
- Wear welding gloves and face shield when using the spot welder. Observers must be protected from flying sparks.
- Prevent excessive "explosion" by proper preparation of work, correct setup, and operation of the spot welder.
- Handle completed spot welded objects carefully as they may be hot and sharp.
- The electrodes are hot and cool slowly after they have been used.
- The electrodes should not be brought together unless a piece of stock is between them.
- Should the electrodes need cleaning, ask the supervisor for help. Do not use a file.

7.7 Sand Blaster

- All work pieces must be clean (free of grease, oil, etc.) and dry.
- You must ask the lab engineer or technician permission to sand blast.
- Discontinue use and inform a lab engineer or technician if the sandblasting machines gloves develop cracks, tears or holes.

7.8 Compressed Air

- Wear safety glasses, goggles, or face shield when using the blowgun.
- Blowing compressed air at your skin or that of others can inject air bubbles into the blood stream and cause death.
- You are responsible for insuring that your use of the air hose does not injure others, (i.e. do not blow chips at someone without eye protection), LOOK FIRST.

7.9 Solvent Tank

- Use of the rubber gloves provided is strongly recommended but not required.
- Pre-clean the parts to remove excess grease, oil and other foreign substances so that the solvent is not instantly too contaminated to use.
- When not in use the lid is to remain closed and not used as a table.
- No additional solvents may be added to the solvent tank.
- The lab engineer or technician is responsible for replacing the solvent.

7.10 Spray Painting

- No spray painting will be done in the labs and workshop shop. It does not meet the Air OSHA regulations and requirements.
- Check with the lab engineer or technician for alternatives if painting is required to complete your project.

7.11 Hydraulic Press

- Make certain work is solidly supported on the table and is aligned with the ram.
- Make certain that accessories, ram or arbor, are properly positioned so as to prevent parts from slipping out when under pressure and endangering yourself or observers.

7.12 Sheet Metal Shear

- Follow the manufacturer's specifications as to gauge of sheet metal that can be safely cut.
- Keep fingers and measuring scales out of the way of the blade.
- Do not cut round stock or anything except sheet metal in the sheer.
- Place the sheet against the guide and then clamp it in position with the clamp on the machine.
- The treadle is operated with one foot, and the other foot must be kept clear as the treadle comes down.
- Return the treadle to the up position slowly with foot pressure. Do not let it make a rapid return.
- Pick up the scrap pieces when you have completed cutting.

7.13 Sheet Metal Brake

- Bend only sheet stock in the brake. No round stock.
- Adjust the clamping bar correctly to suit gauge of metal being formed, and stand clear of the moving part of the brake.

7.14 Throat less Cutter

- Keep fingers clear of the cutter, and handle cut material carefully as it may have sharp edges.
- Do not cut round stock with this cutter.
- Pick up waste once you have completed your cut.

7.15 Wood Tools

- Before using any wood tools, you must inspect your material for foreign metal objects; such as nails, screws, staples, etc.

7.16 Router (Portable)

- Wear a face shield when operating the router.
- Make certain the router bit is tightened before using the router.
- The router cutter must be completely stopped before laying the router down on its side.
- Do not stand the router on the cutter end when not in use.
- Hold the router firmly with both hands before turning on the power.
- Feed the router at a moderate rate; too slow of a feed rate will cause burning of the wood, too rapid a rate will produce a rough splintery surface.

7.17 Saber Saw

- Select the proper blade for the material to be cut, and secure the blade in the saw before plugging in the electric cord.
- Use a relief cut on corners to prevent binding or pinching the blade, which will cause the blade to break.
- Hold the saber saw firmly against the work piece to prevent vibration or injury.
- The saw should be placed on its side on the workbench when not in use.

7.18 Portable Belt Sander

- Place the sander on its side before plugging the power plug into the outlet
- Securely clamp the work piece before sanding.
- Start the sander before touching it to the surface to be sanded.
- Disconnect the power plug before changing the sanding belt.
- The weight of the sander will apply adequate pressure to the sanding surface in most cases. Do not apply pressure that causes the sander to slow down.

7.19 Disk / Belt Sander

- Check the belt or disk to make sure it is in good condition and not torn. The shop supervisor will replace worn belts or disks.
- Keep fingers and hands clear of the moving or rotating surface.
- Hold the work piece securely and use only moderate pressure.
- Sand only on the downward motion side of the disk sander.
- Move the work piece side to side on the sanding surface to prevent rapid wear of the belt or disc.

7.20 Abrasive Wheels

- Grinding wheels should be equipped with tool rests that hold the work firmly.
- Bench and pedestal grinders should be permanently mounted or secured.

- Face shields should always be used when grinding.
- The maximum RPM rating of each abrasive wheel must be compatible with the RPM rating of the grinder motor.
- Each electrically operated grinder should be effectively grounded.
- Each grinder should have an individual “On” and “Off” control switch.
- Abrasive wheels must not be stored where they would be exposed to high temperature or humidity, water or other liquids.
- Before new abrasive wheels are used they should be visually inspected and ring tested.
- Grinding of large parts, prolonged grinding, grinding of potentially toxic materials, and cutting of wheels all require mechanical exhaust ventilation.
- Defective abrasive wheels (cracked, broken, out of balance) should not be used.
- Abrasive wheels which have been discarded should not be re-used.
- Flanges should be of such design as to satisfactorily transmit the driving torque from the spindle to the grinding wheel.
- Flanges may be made of steel, cast iron, or other material of equal or greater strength and rigidity.
- Flanges shall be designed with respect to rigidity so that when tightened, the radial width of bearing surface of contact on the wheel is maintained.
- Abrasive wheels must have cover guards.

7.21 Metal-Cutting Guillotines

The following requirements apply to the safe use of metal-cutting guillotines:

- Guards must be provided to prevent the operator’s fingers from contacting the knife or clamp from either the front or rear of the machine. Only one person should be allowed to operate the machine at the one time and where long material is being cut and cannot be adequately supported by the worktable, additional supports should be provided.
- A hand-operated guillotine should be made inoperative when not in use either by removal of the handle or by the use of a locking or similar device.
- The shear edges of the blades should be maintained in good condition and blade clearance must be adjusted in accordance with the manufacturer’s recommendation appropriate to the thickness of the material being cut.
- Waste scrap metal provides a hazard for the hands and protective gloves should be worn when the metal is handled. A container should be provided for waste material from the guillotine.

7.22 Power Hacksaws

An automatic knock-off switch should be used at all times and a regular check should be carried out to ensure it is in good order. The work must be secured, adequately supported and the length of any overhang should be clearly indicated to avoid it being a hazard to any other person.

8

ELECTRICAL SAFETY

8. ELECTRICAL SAFETY

Many laboratory electrically powered equipment's can pose a significant hazard to laboratory workers, particularly when mishandled or not maintained. Many laboratory electrical devices have high voltage or high-power requirements, carrying even more risk. Electrical shock and fire are the major hazards associated with electricity.

Please do not assume that lab equipment and electrical appliances are de-energized automatically, therefore, "test before you touch" is basic rule of thumb in electrical safety.

- Understand the construction and operation of the electrical equipment and the hazards Involved.
- Identify all possible energy sources that could pose on-the-job hazards.
- Know safety requirements and follow them.
- Select the appropriate personal protective equipment (PPE). Remember, PPE must be worn until the electrical system is in a safe condition.
- Complete a detailed job plan and communicate it to all coworkers involved.
- Before working on or around electrical systems or equipment, identify the load circuits and disconnect. Remember, in some cases, turning power off may cause other hazards. Such hazards and additional guidance should be addressed in your work plan.
- Verify that the equipment or system has been de-energized by testing.
- Make sure your test equipment is working; both before and after you use it.
- If at any time the job becomes more hazardous than anticipated, stop and revises the plans.

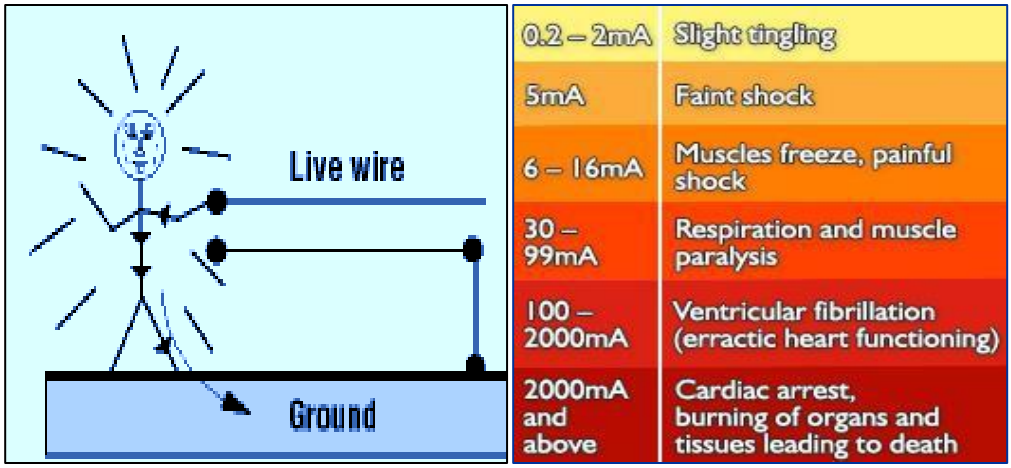
8.1 Electrical Hazards

The severity and effects of an electrical shock depend on a number of factors, such as:

- The pathway through the body.
- The amount of current,
- The length of time of the exposure, and
- Whether the skin is wet or dry.

The chart below shows the general relationship between the degree of injury and amount of current for a 50–60 cycle hand-to-foot path of one second's duration of shock. While reading this table, keep in mind that most electrical circuits can provide, under normal conditions, up to 20,000 milli-amperes of current flow.

Keeping in mind that the electrical shock hazards, sparks from electrical equipment can serve as an ignition source for flammable or explosive vapors or combustible materials.



Source, University of Princeton: https://ehs.princeton.edu/book/export/html/75

Power loss

The following hazardous situations can be created due to the Loss of electrical power:

- If magnetic or mechanical stirrers fail to operate, safe mixing of reagents may be compromised.
- Fume hoods may cease to operate, allowing vapors to be released into the laboratory.
- Flammable or toxic vapors may be released as a chemical warms when a refrigerator or freezer fails.

8.1 Preventing Electrical Hazards

There are various ways of protecting people from the hazards caused by electricity, including insulation, guarding, grounding, and electrical protective devices.

8.1.1 Insulation

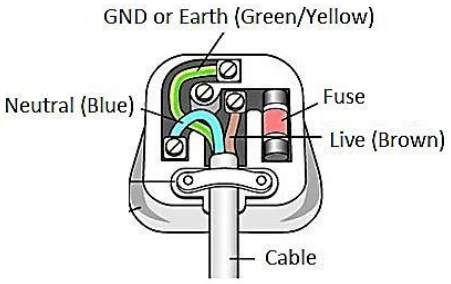
All electrical cords should have sufficient insulation to prevent direct contact with wires. In a laboratory, it is particularly important to check all cords before each use, since corrosive chemicals or solvents may erode the insulation. Damaged cords should be repaired or taken out of service immediately.

8.1.2 Guarding

Live parts of electric equipment operating at 50 volts or more (must be guarded against accidental contact. Plexiglas shields may be used to protect against exposed live parts.

8.1.3 Grounding

Only equipment with three-prong plugs should be used in the laboratory. The third prong provides a path to ground for internal electrical short circuits, thereby protecting the user from a potential electrical shock.

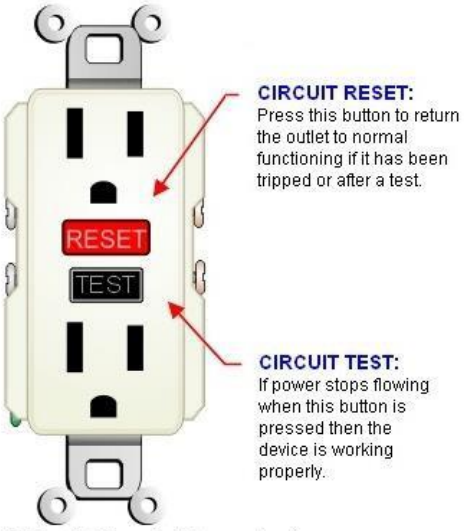


8.1.4 Circuit protection devices

Circuit protection devices, such as fuses, circuit breakers, ground-fault circuit interrupter, are designed to automatically shut off the flow of electricity in the event of a ground-fault, overload or short circuit in the wiring system.

- Fuses and circuit breakers prevent over-heating of wires and components that might otherwise create fire hazards. They disconnect the circuit when it becomes overloaded. This overload protection is very useful for equipment that is left on for extended periods of time, such as stirrers, vacuum pumps, drying ovens, and other electrical equipment.

- The ground-fault circuit interrupter, or GFCI, is designed to shutoff electric power if a ground fault is detected, protecting the user from a potential electrical shock. The GFCI is particularly useful near sinks and wet location.



(Ground Fault Circuit Interrupter)

Source, https://www.egr.msu.edu/eceshop/cleanroom/safety/lab/electrical_safety.pdf

8.1.5 Motors

All newly purchased equipment should have spark-free induction motors. The on-off switches and speed controls may be able to produce a spark when they are adjusted because they have exposed contacts. Any switches located on the device should be removed and insert a switch on the cord near the plug end.

Laboratory workers can significantly reduce electrical hazards by following some basic precautions:

- Inspect wiring of equipment before each use. Replace damaged or frayed electrical cords immediately.
- Use safe work practices every time electrical equipment is used.
- Know the location and how to operate shut-off switches and/or circuit breaker panels. Use these devices to shut off equipment in the event of a fire or electrocution.
- Limit the use of extension cords. Use only for temporary operations and then only for short periods of time. In all other cases, request installation of a new electrical outlet.
- Multi-plug adapters must have circuit breakers or fuses.
- Place exposed electrical conductors (such as those sometimes used with electrophoresis devices) behind shields.
- Minimize the potential for water or chemical spills on or near electrical equipment.

8.2 Safe Work Practices

The following are a list of rules for working with electrical equipment:

- Turn off the power to equipment before inspecting it.
- Check circuits for proper grounding with respect to the power source.
- Never change wiring with circuit plugged into power source.
- Never plug leads into power source unless they are connected to an established circuit.
- Keep access to electrical panels and disconnect switches clear and unobstructed.
- Tools and equipment with non-conducting handles should be used when working with electrical devices.
- All current transmitting parts of any electrical devices must be enclosed.
- When checking an operating circuit keep one hand either in a pocket or behind your back to avoid making a closed circuit through the body.
- Avoid contacting circuits with wet hands or wet materials.
- Wet cells should be placed on a piece of non-conducting material.
- Do not insert another fuse of larger capacity if an instrument keeps blowing fuses – this is a symptom requiring expert repairs.
- Extension cords must be connected to a power strip equipped with a fuse.
- Maintain a workspace clear of extraneous material such as books, papers, and clothes.
- Do not use or store highly flammable solvents near electrical equipment.
- Multi-strip outlets (cube taps) should not be used in place of permanently installed receptacles. If additional outlets are required have them installed by an electrician.

What to Do in Case of Electric Shock

- **If the victim seems held by the current or is still in contact with it;**
  - Don't touch the victim. You might get a shock, too!
  - Disengage the victim from the electric current by Cutting the power at the source or using a nonconductive object to free the victim from the energy source without touching him or her directly.
  - Call an ambulance, a witness to the accident should preferably accompany the victim to emergency.

- **If the victim is unconscious, has stopped breathing or has no detectable pulse after being released from the current,** perform cardiopulmonary resuscitation (CPR) until the ambulance arrives. A severe electric shock may cause cardiac arrest. But if the heart is uninjured, CPR can be extremely effective.

8.3 Spark Hazards

Proper grounding of equipment and containers is necessary to avoid sparks. Sparks may result in explosions in areas where flammable liquids are being used. Some common potential sources of sparks are:

- The making and braking of an electrical circuit when the circuit is energized.
- Metal tanks and containers.
- Plastic lab aprons.
- Metal clamps, nipples, or wire used with no conducting hoses.
- High-pressure gas cylinders upon discharge.

8.4 Electrostatic Discharge Hazard and Protection

Human beings and objects get electrostatically charged by different sources. For example, walking on a dry floor in non-humid environment generates sufficient static electricity to be damage the electronic devices. Work surfaces, floors, clothes, chairs, and packaging material are typical sources if static electricity. For example, walking on a vinyl tile floor can generate the static voltage of 12,000 V when the relative humidity is less than 20% and the voltage of 250 V when the relative humidity is between 60%-and 90%.

How does damage from ESD happen? When a statically-charged person or object touches an electrostatic discharge sensitive (ESDS) device, there is a possibility that the electrostatic charge could be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage could occur in the device due to localized overheating.

A commonly used tool for the detection of static charges is the electrostatic field meter. The ESD sensitive electric equipment can be protected by taking the safety measures such as:

- It is essential to handle ESD devices at static-safe workstations.
- Use antistatic wrist-straps, use ESD safe solder and rework station to repair the ESD sensitive equipment.

- Remove items that are composed of insulated materials at a static-safe workstation.
- Use an air ionizer designed to neutralize electrostatic charges.
- Avoid bringing sources of static electricity within 1meter of a static-safe work bench.
- Use the ESD danger sign to alert the user to take the ESD protection measure while using the ESD sensitive equipment.

Source: See for example, http://www.minicircuits.com/app/AN40-005.pdf

8.5 High Voltage or Current

Voltages greater than 50 V applied across dry unbroken human skin can cause heart fibrillation if they produce electric currents in body tissues that happen to pass through the chest area. The danger related to the high voltage is discussed in section 8.1. Only trained electricians should repair of high voltage or high current equipment.

- Don't touch the HV equipment's before properly discharging to ground.
- High voltage cables must not be in the path way under any condition.
- Don't pass the H.V warning tape during the operation of the HV equipment.
- Before starting the work make sure the power was switched off and you are the one operating the equipment.
- All heating devices (e.g. soldering tools) should be carefully operated and turned off before leaving the lab.
- Do not work alone in the Lab.

Further resources: Electrical Safety and Health for Electrical Trades Student Manual, available at http://www.cdc.gov/niosh/docs/2009-113/pdfs/2009-113.pdf

9

FIRE SAFETY

9. FIRE SAFETY

Call 9-997 and report the location of the fire

Fire extinguishers are classified according to the type of fire they can effectively extinguish.

Fire Class	Material
Class A	Wood, paper, and clothing, which produce glowing embers or char.
Class B	Flammable gases, liquids, and greases, including gasoline and most hydrocarbon liquids which must be vaporized for combustion to occur
Class C	Electrical equipment or in materials near electrically powered equipment
Class D	Combustible metals, such as magnesium, zirconium, potassium, and sodium

9.1 Fire Extinguishers

9.1.1. Types of Extinguishers

Carbon dioxide (CO_2) extinguishers

These extinguishers are intended primarily for use on Class B and Class C fires.

- Initial application must start reasonably close to the fire.
- On all fires the discharge should be directed at the base of the flames.
- CO_2 discharge should be applied to the burned surface even after the flames are extinguished, to prevent possible re-flash.
- In case of flammable liquid fires, apply the discharge from the fire extinguisher first at the near edge of the fire and gradually progressing forward in order to get the best results.

Dry chemical (ABC) extinguishers

Dry chemical extinguishers are intended for use on Class A, Class B, and Class C fires.

- The discharge should be directed at the base of the flames.
- Attack the near edge of the fire and progressing forward, moving the nozzle rapidly with a side-to-side sweeping motion for best results.
- Don not blast flaming liquid around the area.
- To prevent possible re-flash continue discharge after flames are extinguished.
- For Class A fires the discharge should be continued intermittently to coat flowing areas of Class A materials.

Dry powder extinguishing agent (d)

Dry powder extinguishing agent is intended primarily for use on metal fires.

- The application of the agent should be of sufficient depth.
- Cover any hot spots by additional applications of dry powder.
- Avoid scattering of the burning metal.

9.2. Location and Marking of Extinguishers

Extinguishers should be properly located clearly visible and easily accessible for immediate use in the case of fire. Directional arrows will be provided to indicate the location of extinguishers, in locations where visual obstruction cannot be completely avoided. All extinguishers should be labeled indicating clearly the type of fire used for.

9.3. Condition

Portable extinguishers will be maintained in a fully charged and operable condition. They will be kept in their designated locations at all times when not being used. When extinguishers are removed for maintenance or testing, a fully charged and operable replacement unit will be provided.

9.4. Distribution and Mounting of Extinguishers

Extinguishers must be distributed in such a way that the amount of time needed to travel to their location and back to the fire does not allow the fire to get out of control. Extinguishers are installed on hangers, brackets, in cabinets, or on shelves. Extinguishers having a gross weight not exceeding 40 pounds will be so installed that the top of the extinguisher is not more than 3-1/2 feet above the floor. Extinguishers mounted in cabinets or wall recesses or set on shelves will be placed so that the extinguisher operating instructions face outward.

9.5. Inspection and Maintenance

It is the responsibility of the Lab Engineer/Technician to oversee the inspection, maintenance, and testing of fire extinguisher to ensure that they are in proper working condition and have not been tampered with or physically damaged.

9.6 Fire Alarm

- In the event of a fire emergency, a fire alarm shall sound for the building.
- Upon hearing the fire alarm, a loud bell, all persons shall evacuate the building and assemble in the designated Assembly Area outside the building.
- All persons shall evacuate, unless a testing of the fire alarm system is announced.
- The person setting off the alarm should call the Fire Department at **9-997** and campus security **03-713-8000**, and verify the emergency.
- Fire alarms shall be tested once per month.

9.7 Fire Drills

Fire drills should be performed at least once per year. All personnel and Users shall participate, with NO exceptions. All personal involved in the fire drill should be informed ahead of time. All personnel shall evacuate, as in a real fire, to the designated assembly area.

9.8 Fire Emergency Procedures

If you discover a fire:

- Activate the nearest fire alarm.
- Notify the Fire Department by dialing **9-997**. Give your location, the nature of the fire, and your name.
- Notify Chair of the Department and other occupants.

Fight the fire ONLY if:

- The fire department has been notified of the fire, AND
- The fire is small and confined to its area of origin, AND
- You have a way out and can fight the fire with your back to the exit, AND
- You have the proper extinguisher, in good working order, AND know how to use it. If you are not sure of your ability or the fire extinguisher's capacity to contain the fire, leave the area.

If you hear a fire alarm:

- Evacuate the area. Close windows, turn off gas jets, and close doors as you leave.

- Leave the building and move away from exits and out of the way of emergency operations.
- Assemble in a designated area.
- Report to the campus security so he can determine that all personnel have evacuated your area.
- Remain outside until competent authority states that it is safe to re-enter.

Evacuation Routes

- Learn at least two escape routes, and emergency exits from your area.
- Never use an elevator (as in the Mechanical Engineering Department Building) as part of your escape route.
- Learn to activate a fire alarm.
- Learn to recognize alarm sounds.
- Take an active part in fire evacuation drills.

9.9 FIRE PROTECTION SYSTEMS

The shared laboratory buildings at Maqam Campus are now protected by automatic sprinkler systems. Labs without sprinkler protection were designed with the presence of 2-hour fire barriers separating adjacent areas of the building. Additionally, the server rooms are protected by clean agent suppression systems in lieu of automatic sprinkler protection. The buildings are also protected by standpipe systems consisting of landing valves and occupant use hose reels located outside each stair. Additionally, portable fire extinguishers are distributed throughout each floor [See Fire Alarm Systems in Hazardous Material Protection Brief I54921, pp. 9-10].

Manual and automatic fire alarm systems are installed throughout the shared laboratory buildings. The shared laboratory buildings are protected throughout by detection devices that will automatically notify the building occupants upon alarm. In addition to occupant notification, activation of an alarm will permit the continued operation of the corridor ventilation system for 180 seconds prior to shutting down the AHUs and closing the fire/smoke dampers. The fume hoods within the laboratories will remain operational upon activation of the alarm. The fire alarm system will be activated upon smoke detectors, heat detectors, duct detectors, sprinkler water-flow switch, manual pull stations, or activation of a clean agent system. The building Fire Alarm Panels are located at the main entrance lobby to each building. The Fire Alarm Panel includes a handset capable of issuing manual instructions to each area of the building. The shared laboratory buildings also include gas detection systems to detect leakage from the LPG system. The main gas detection control panel is located adjacent to the fire alarm control panel in each building with additional remote panels located within each laboratory supplied with LPG. Upon activation of the gas detection system, the gas detection systems will automatically isolate the supply of LPG and a trouble signal will be activated at the fire alarm control panel. Additionally, activation of the fire alarm system will initiate isolation of the LPG supply to the building.

Table 11 in RJA Report, 2013, depicts the maximum allowable quantities of fire hazardous materials stored in the lab. The lab engineer and/or technician shall insure that the amounts are not exceeded at any time.

Table 11 – NFPA 5000 Maximum Allowable Quantities per Control Area

HAZARDOUS MATERIAL	CLASS	STORED QUANTITIES		
		SOLID KG (m^3	LIQUID L (KG)	GAS m^3
Combustible Liquids	II	-	908*	-
	IIIA	-	2500*	-
	IIIB	-	50000*	-
Consumer Fireworks	1.4G	114*	-	-
Cryogenic Liquid	Flammable	-	341	-
	Oxidizing	-	341	-
Explosives	-	0.5*	(0.5) *	-
Flammable Gas	Gaseous	-	-	56.6*
	Liquefied	-	227*	-
	Liquefied Petroleum	-	1140	-
Flammable Liquid	IA	-	227*	-
	IB and IC	-	908*	-
	Combination	-	908*	-
Flammable Solid		114*	-	-

Organic Peroxide	Unclassified Detonatable	0.5*	(0.5) *	-
	I	4.5*	(4.5) *	-
	II	45.4*	(45.4) *	-
	III	56.8*	(56.8) *	-
	IV	NL	NL	-
	V	NL	NL	-
Oxidizer	4	0.5*	(0.5) *	-
	3	9.1*	(9.1) *	-
	2	227*	(227)*	-
	1	1820*	(1820) *	-
Oxidizing Gas	Gaseous	-	-	84.9*
	Liquefied	-	114*	-
Pyrophoric	-	1.8*	(1.8) *	1.4*
Unstable (reactive)	4	0.5*	(0.5) *	0.3*
	3	4.5*	(4.5) *	2.8*
	2	45.4*	(45.4) *	42.4*
	1	NL	NL	NL
Water-reactive	3	4.5*	(4.5) *	-
	2	45.4*	(45.4) *	-
	1	NL	NL	-
Corrosive	-	4540*	3790*	45.8*
Highly Toxic	-	9.1*	(9.1)*	1.1
Toxic	-	454*	(454)*	45.8*

For more information on fire safety, visit RJA Report, 2013 (Hazardous Material Protection Brief, UAE University, Shared Laboratories, Al Ain, UAE).

10

HAZARDOUS WASTE DISPOSAL

10. HAZARDOUS WASTE DISPOSAL

The purpose of environmentally sound disposal methods is to prevent harm to the water, land, and air.

10.1 Definitions

Waste: Any useless and valueless material that is to be discarded.

Generator: Any person, by site, who produces municipal hazardous waste or industrial solid waste; any person who possesses municipal hazardous waste or industrial solid waste to be shipped to any other person; or any person whose act first causes solid waste to become subject to regulation.

Hazardous waste*:* Any solid waste material listed or identified in Title 40 Code of Federal Regulations, Part 261, Subpart C or D or exhibiting the characteristics of ignitability, corrosivity, reactivity, or E.P. toxicity also defined in Part 261. Tables containing the listing and characteristics of hazardous wastes are shown at the end of this chapter.

Mixed waste*:* A radioactive waste that is also a hazardous waste.

Solid waste: Any garbage, refuse, sludge from a waste treatment plant, water treatment plant, or air pollution control facility or other discarded material. Solid waste can be solid, liquid, semi-solid, or contained gaseous material resulting from industrial, municipal, commercial, mining and agricultural operations, and from community and institutional activities.

Disposal*:* The discharge, deposit, injection, dumping, spilling, or placing of any solid waste or hazardous waste (whether containerized or containerized) into or on any land or water so that such solid waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any water, including ground waters.

10.2 Types of Hazardous Waste

An item is considered waste when the owner determines that the material is no longer useful and needs to be discarded. An item is considered to be hazardous waste if it meets one or more of the following characteristics:

- A chemical component is listed as hazardous by MSDSs. See for example, MSDSs.
- Mixture contains a listed hazardous waste and a nonhazardous waste.
- Material meets the definition of one of the following:
    - Ignitability (flashpoint <60°C or supports combustion)
    - Reactivity (e.g., water reactive, cyanides, explosives, unstable chemicals)
    - Corrosivity (pH <4 or >10)
    - Environmental Protection (EP) toxicity (e.g., pesticides, heavy metals, poisons)
- Material is not excluded from regulations.

Individual Lab Engineer/Technicians are responsible for properly identifying the hazardous waste they generate and for following proper disposal procedures. Refer to the MSDSs for list of regulated hazardous chemicals.

10.3 Containers, Tags, and Collection

Proper containment, tagging, collection and disposal are essential to the success of the Hazardous Waste Program. The following sections discuss these areas.

10.3.1 Containers

Hazardous waste collection containers must be in good condition, must not leak, and must be compatible with their hazardous contents (e.g., do not use metal containers for corrosive waste or plastic containers for organic solvents). All containers must have suitable screw caps or other secure means of closure.

If you are reusing a container to accumulate waste, destroy the original product label. EPA regulations require that waste containers be labeled with the accumulation start date, the identity of the contents, and the words "Hazardous Waste". Use a new label to identify the hazardous waste; do not use the disposal tag for this purpose.

Important: Never overfill hazardous waste containers. Expansion and excess weight can lead to spills, explosion, and extensive environmental exposure.

Hazardous waste containers for liquids are generally rated by volume capacity. Allow extra room in liquid containers to allow for contents expansion.

- Do not fill jugs and bottles past the shoulder of the container.
- Fill closed head cans (5 gallons or less) to leave approximately two inches of space between the liquid level and the top of the container.
- Fill closed head drums (Larger than 5 gallons) to leave approximately four inches of space.

Generally hazardous waste containers for solids are rated by their weight capacity and volume capacity. Take care not to exceed the weight capacity of a solid container. Weight is generally not a problem for jars and open head cans (5 gallons or less), but it can be a problem for open head drums (larger than 5 gallons). Depending on weight requirement, you may fill containers for solids within two inches

of the closure.

Important: Keep all waste collection containers closed except when adding or removing material.

10.3.2 Completing tags

A waste disposal tag must be attached to each waste container before disposal. Follow these guidelines for completing hazardous waste tags:

- Completely fill out the tag. (This information is essential for record keeping.)
- The "Lab Engineer/Technician" is the person in charge of the lab.
- Use full chemical names or common names. Chemical formulas or abbreviations are not acceptable.
- List all chemical components in the waste container, including water.
- Indicate the % concentration of potentially explosive materials such as picric acid and nitro compounds.
- Place additional hazard information in REMARKS.
- Stick the tag to the container, keep a copy of the tag in the lab records and send a copy to the chair of the department.

United Arab Emirates University

College of Engineering

HAZARDOUS WASTE

Department ----------

Phone ----------

Lab ----------

Responsible Individual ----------

Storage Date ----------

Contents	Approximate %
----------	----------
----------	----------
----------	----------
----------	----------

Hazards Class

1. Poison, 2. Flammable Liquid, 3. Flammable Solid,

4. Oxidizers, 5. Corrosive, 6. Peroxide Former, 7. Sensitive to Shock Air or Water

10.3.3 Collection and disposal

The college will arrange for disposal after receiving a properly completed waste disposal tag from the Chairman of the Department. Containers with improper caps, leaks, outside contamination, or improper labeling will not be picked up until these problems have been corrected.

Improper disposal methods for hazardous chemical waste include the following:

- Disposal down the drain.
- Intentional evaporation in a fume hood.
- Disposal in the regular trash.

10.4 Disposing of Empty Containers

The disposing of empty containers must meet the following requirements:

- Product labels must be defaced or removed.
- Container lids or caps must be removed.
- Containers must not contain free liquid or solid residue.
- Containers must be triple rinsed.
- It is not necessary to break empty glass containers.

- Punch holes in the bottom of metal containers and plastic jugs before disposing of them in the regular trash.

Important: Containers that do meet the requirements mentioned here must be treated as hazardous waste.

10.5 Reduction of Waste Source

Lab Engineer/Technician should adhere to the following techniques to reduce waste sources:

10.5.1 Purchasing and inventory control

- Computerized tracking systems to manage purchasing and control inventory should be used.
- The current inventory records should be maintained to prevent overstocking and to monitor the shelf life of remaining materials.
- A campus-wide chemical exchange network should be developed to promote chemical sharing and avoid redundant purchases.
- Compressed gases should be obtained from vendors who accept return of empty or partially full cylinders.
- Waste generation should be considered as a criterion in equipment selection.
- Chemical stocks should be rotated in order to use chemicals before their shelf life expires.

10.5.2 Chemical usage

- Spills and waste should be Reduce by pre-weighing chemicals for undergraduate use.
- Proper labeling is requiring of all secondary containers.
- All deteriorating labels should be replaced on all containers.
- The use of heavy metals should be minimized (e.g., silver, chromium, mercury, barium, cadmium, and lead).
- Alcohol or electronic thermal monitors should be used instead of for mercury thermometers.
- NoChromix, detergents, or enzymatic cleaners should be used to clean laboratory glassware.
- Solvent waste should be minimized by recycling or substitution.

10.6 Waste Minimization Techniques

Lab engineers/technicians should follow these techniques to reduce hazardous waste:

- Review waste streams and recommend waste minimization procedures.
- Do not mix different types of waste.

- Do not put non-hazardous waste, such as a mixture of water, sodium bicarbonate, and acetic acid, into a waste container of hazardous waste.
- Do not combine inorganic heavy metal waste with organic solvents waste.
- Segregate halogenated waste solvents from non-halogenated waste solvents.
- Segregate waste streams by storing them in separate waste containers.
  - Store waste containers separate from reagent containers being used to avoid accidental contamination.
  - Decontaminate empty containers to make them non-hazardous.
  - Neutralize or dilute acids and bases to make them non-hazardous and suitable for drain disposal.
  - When possible, redesign experimental protocols so that harmful byproducts are detoxified or reduced.
  - Recycle chemicals via purification.

10.7 Waste Segregation

Many hazardous wastes, when mixed with other waste or materials, can produce effects which are harmful to human health and the environment, such as

- Heat or pressure,
- Fire or explosion,
- Violent reaction,
- Toxic dusts, mists, fumes, or gases, or
- Flammable fumes or gases.

Segregated waste is safer and easier to dispose of than non-segregated waste. Mixed waste as indicated above can result in severe consequences.

Each Lab Engineer/Technician or research assistant who generates waste is personally responsible for the following:

- Ensuring that hazardous wastes are accumulated in safe, transportable containers.
- Ensuring that hazardous wastes are stored properly to prevent possible exposure.

10.8 Incompatible Waste

Below are examples of potentially incompatible wastes, waste components, and materials, along with the harmful consequences, which result from mixing materials in one group with materials in another group. This list is not intended to be exhaustive. A waste generator must, as the regulations require, adequately control his wastes so that he can avoid creating uncontrolled substances or reactions of the type listed below, whether they are listed below or not. It is possible for potentially incompatible wastes to be mixed in a way that precludes a reaction (e.g., adding acid to water rather than water to acid) or that neutralizes them (e.g.,

a strong acid mixed with a strong base), or that controls substances produced (e.g., by generating flammable gases in a closed tank equipped so that ignition cannot occur, and burning the gases in an incinerator). In the lists below, the mixing of a Group A material with a Group B material may have the potential consequence as noted.

Group A	Group B	Consequences
1-A) Acetylene sludge, Alkaline caustic liquids, Alkaline cleaner, Alkaline corrosive liquids, Alkaline corrosive battery fluid, Caustic wastewater, Lime sludge and other corrosive alkalis, Lime wastewater, Lime and water Spent caustic	**1-B**) Acid sludge, Acid and water, Battery acid, Chemical cleaners, Electrolyte, acid, Etching acid liquid or solvent, Pickling liquor and other corrosive acids. Spent acid, spent mixed acid, Spent sulfuric acid	Potential consequences: Heat generation; violent, reaction.
2-A) Aluminum, Beryllium, Calcium, Lithium, Magnesium, Potassium, Sodium, Zinc powder, Other reactive metals and metal hydrides	**2-B**) Any waste in Group 1-A or 1-B	Potential consequences: Fire or explosion; generation, of flammable hydrogen gas.
3-A) Alcohols, Water	**3-B**) Any concentrated waste in Groups 1-A or 1-B, Calcium, Lithium, Metal hydrides, Potassium, SO_2Cl_2, $SOCl_2$, PCl_3, CH_3SiCl_3, Other water-reactive waste	Potential consequences: Fire, explosion, or heat generation; generation of, flammable or toxic gases.
4-A) Alcohols, Aldehydes, Halogenated hydrocarbons, Nitrated hydrocarbons, Unsaturated hydrocarbons, Other reactive organic compounds and solvents	**4-B**) Concentrated Group 1-A or 1-B wastes, Group 2-A wastes	Potential consequences: Fire, explosion, or violent reaction
5-A) Spent cyanide and sulfide solutions	**5-B**) Group 1-B wastes	Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas.
6-A) Chlorates, Chlorine, Chlorites, Chromic acid, Hypochlorites, Nitrates, Nitric acid, fuming, Perchlorates, Permanganates, Peroxides, Other strong oxidizers	**6-B**) Acetic acid and other organic acids, concentrated mineral acids, Group 2-A wastes, Group 4-A wastes, Other flammable and combustible wastes	Potential consequences: Fire, explosion, or violent reaction

Source: "Law, Regulations, and Guidelines for Handling of Hazardous Waste." California Department of Health, February 1975. See for example, https://www.colorado.gov/pacific/sites/default/files/Part-265-Appendix-I-III-VI-eff-07-02-06.pdf

10.9 Segregation Classification

In addition to the guidelines for waste minimization and substitution, follow these guidelines for waste segregation:

- Segregate waste into the following groups:
    - Halogenated solvents

- Non-halogenated solvents
- Acids
- Bases
- Heavy metals
- Poisons
- Reactive materials

- Do not mix non-hazardous waste, such as water, with hazardous waste.
- Do not combine inorganic heavy metal waste with organic solvent waste in hazardous waste containers.
- Double-bag dry materials contaminated with chemicals (paper, rags, towels, gloves, etc.) in heavy-duty plastic bags. Do not use biohazard bags**.** Dispose of these items in the same manner as hazardous waste.
- Encapsulate sharps (e.g., needles, razor blades, etc.) then place them in trash dumpsters.

10.10 Special Concerns

Persons who generate hazardous waste must maintain and control their hazardous waste accumulation areas. Special concerns for hazardous waste include the following:

- Unneeded chemicals that are to be discarded must be handled and managed as hazardous waste.
- Gas cylinders are extremely difficult to discard. They should be returned to the manufacturer or distributor whenever possible. Cylinders that cannot be returned should be tagged as hazardous waste as soon as possible.

11

SAFETY TRAINING

11. SAFETY TRAINING

11.1. Information and Training Program

The College of Engineering requires that all individuals that work in a laboratory are adequately informed about the physical and health hazards present in the laboratory, the known risks, and what to do if an accident occurs.

Every laboratory/workshop worker must be trained to know the location and proper use of available personal protective clothing and equipment. See chapter four of this manual for information on the use of personal protective clothing and equipment. The laboratory engineer and/or technician is responsible for providing information to his or her personnel about any hazards present in the lab or workshop. This information must be provided at the time of a lab or workshop person's initial assignment and prior to any assignments involving new potential hazards situation. The following lists the information that should be provided by the lab engineer and technician:

- The location and availability of this manual;
- The OSHA Occupational Exposure to Hazardous Chemicals in Laboratories standard http://www.osha.gov/
- The location and availability of known reference material on the hazards, safe handling, storage, and disposal of hazardous chemicals found in the laboratory including, but not limited to, MSDSs received from the chemical supplier;
- The permissible exposure limits (PEL) for OSHA regulated substances or recommended exposure limits (for example, TLV) for other hazardous chemicals where there is no applicable OSHA standard (see OSHA Permissible Exposure Limits of some common laboratory chemicals). Other significant values may be found on the appropriate MSDS;
- Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory;
- Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as continuous monitoring devices, and visual appearance or odor of hazardous chemicals when being released);
- The physical and health hazards of chemicals in the work area;
- The applicable details of this manual.

Lab engineers and technicians must be re-trained when new equipment or chemical hazards are introduced into their workplace, as well as upon reassignment to different workplaces that involve new equipment or chemical hazards. The lab engineer or technician must conduct site-specific training. Basic safety training is required for all employees of The College, including faculty, staff, and students who have the potential for exposure to hazardous chemicals. Training is required before the employee can be assigned work in or

around hazardous chemicals, but annual refreshers are not required. The training takes approximately one hour and includes:

- Central requirements of the basic, including training, chemical labels, and MSDSs;
- Spill clean-up and chemical disposal procedures;
- Chemical storage guidelines; and
- Hazards specific to different chemical groups.

11.2. Laboratory Safety Training

Laboratory safety training is required for all employees of The College, including faculty, staff, and students who may work in a laboratory that contains hazards equipment or using hazardous chemicals or biological materials. This training must be received prior to the beginning of a laboratory assignment. The training takes approximately one hour (1/2 lab session) and should include:

- Fire protection and fire alarm system at E5 labs;
- Occupant use hose reels and landing valves located outside each stair;
- Safety equipment and practices;
- Emergency procedures;
- Emergency equipment; and
- Waste disposal.

11.3. Fire Extinguisher Training

Fire extinguisher training, with live fire suppression, is required for all laboratory engineers, technicians and research assistant. This training covers what to do in the event of a fire, the behavior of fire and how it spreads, the classes of fires, and the proper selection and use of a fire extinguisher. This training program will familiarize laboratory workers with the general principles of fire extinguisher use; give them confidence in their ability to operate the extinguisher; and remove some of the fear associated with putting out a fire by showing them that fire extinguishers do work in putting out fires. The safety committee should plan once a year for a life fire drill (fire- fighting workshop).

11.4. Waste Management Training

Waste management training is required for selected employees of the College, including faculty, staff, and graduate students who are in laboratory supervisory positions where hazardous chemicals or biological materials are in use. Principal Investigators must choose a minimum of one individual for every eight paid members of the Pis group to attend this training. In other words, if a PI has from up to 8 graduate students, post-docs, or staff members then at least one must be chosen to receive training, if there are 9-16 members then at least two must receive training, and so on. Additionally, all staff members that have any supervisory or coordination responsibilities for teaching labs must receive this training. Every teaching lab must have one or more individuals that have received this training and are responsible for following the procedures

included in the training. Technical & Safety Training Centers offer this training on a regular schedule and can arrange special sessions with advance notice. The training takes approximately one hours and includes:

- Hazardous waste definitions and regulatory environment;
- Spill clean-up and chemical waste disposal procedures;
- Chemical waste storage and segregation guidelines; and
- Waste minimization and drain disposal.

11.5. Biosafety Training

Biosafety training is required for concerned employees of The College, including faculty, staff, and graduate students who work in laboratories where infectious agents are in use. The training takes less than one hours and may include, as appropriate to the attendees:

- Universal precautions;
- Spill clean-up; and
- Practices and equipment required for work at different biosafety levels.

11.6. Online Safety Training Modules

These modules are courtesy of the following website:

http://sc.edu/search?q=ehs.sc.edu%2Ftraining#gsc.tab=0&gsc.q=ehs.sc.edu%2Ftraining&gsc.page=1

Click on the course name to access online training. Make sure that you follow instructions to ensure that your training is properly documented and that you receive credit for having received training.

• Asbestos Information www.sc.edu/ehs/IH/**Asbestos**2.html	• Hazard Communication
• Back Safety	• Laboratory Safety www.sc.edu/ehs/**LabSafety**.htm
• Blood-borne Pathogens	• Ladder Safety
• Confined Space Entry	• Lockout/Tagout
• Electrical Safety	• Noise and Hearing Conservation
• Fire Extinguishers	• Personal Protective Equipment
• Forklift Safety	

APPENDICES

Appendix I: List of Explosives

- Ammonium nitrate-fuel oil mixture.
- Ammonium nitrate, (with more than 0.2 % combustible substances, by mass)
- Ammonium perchlorate.
- Ammonium picrate, (dry or wetted with less than 10 % water, by mass)
- Azo-di-iso-butyronitrile.
- Barium azide (dry or wetted with less than 50 % water, by mass)
- Barium styphnate.
- Cyclotetramethylene-tetranitramine, desensitized (or) Octogen, desensitized (or) HMX, desensitized.
- Cyclotetramethylene-tetranitramine, wetted (or) HMX, wetted (or) Octogen, wetted (with not less than 15 % water, by mass).
- Cyclotrimethylenetrinitramine, desensitized (or) Cyclonite, desensitized (or) Hexogen, desensitized (or) RDX, desensitized, Hexogen, RDX, desensitized.
- Cyclotrimethylenetrinitramine, wetted (or) Cyclonite, wetted (or) Hexogen, wetted (or) RDX, wetted (with not less than 15 % water, by mass).
- Deflagrating metal salts of aromatic nitro derivatives.
- 2-Diazo-1-Naphthol-4-Sulpho chloride.
- 2-Diazo-1-Naphthol-5-Sulpho-Chloride.
- Diazo dinitrophenol, wetted with not less than 40 % water or mixture of alcohol and water, by mass.
- Diethylene glycol dinitrate, desensitized (with not less than 25 % non-volatile water-insoluble phlegmatizer, by mass.
- Dinitroglycoluril (or) Dingu.
- Dinitro-phenol, (dry or wetted with less than 15 % water, by mass).
- Dinitro-phenolates (alkali metals, dry or wetted with less than 15 % water, by mass).
- Dinitro-resorcinol, (dry or wetted with less than 15 % water, by mass).
- N,N'-Dinitroso-N-N'-dimethyl terephthalamide not more than 72% as a paste.
- N,N'-Di-nitroso-penta-methylene tetra-amine not more than 82% with phlegmatizer
- Dinitrosobenzene.
- Dipicryl sulfide, (dry or wetted with less than 10 % water, by mass).
- Guanyl nitrosaminoguanylidene hydrazine, wetted (with not less than 30 % water, by mass).
- Guanyl nitrosaminoguanyl tetrazine, wetted (or) Tetrazine, wetted (with not less than 30 % water or mixture of alcohol and water, by mass).
- Hexanitrodiphenylamine (Di-picryl amine; Hexyl)
- Hexanitrostilbene
- Hexatonal, cast
- Hexolite, (dry or wetted with less than 15 % water, by mass).
- Lead azide, wetted (with not less than 20 % water or mixture of alcohol and water, by mass).
- Lead mono-nitro-resorcinate.
- Lead styphnate, wetted (or) Lead tri-nitro-resorcinate, wetted (with not less than 20 % water or mixture of alcohol and water, by mass).

- Mannitol hexa-nitrate (Nitro-mannite), wetted (with not less than 40 % water, by mass or mixture of alcohol and water).
- 5-Mercaptotetrazol-1-acetic acid.
- Mercury fulminate, wetted (with not less than 20 % water, or mixture of alcohol and water, by mass.
- Nitro urea.
- 5-Nitrobenzotriazol.
- Nitrocellulose, (dry or wetted with less than 25 % water [or alcohol], by mass).
- Nitrocellulose, plasticized (with not less than 18 % plasticizing substance, by mass).
- Nitrocellulose, (unmodified or plasticized with less than 18 % plasticizing substance, by mass).
- Nitrocellulose, wetted (with not less than 25 % alcohol, by mass).
- Nitroglycerin, desensitized (with not less than 40 % non-volatile water insoluble phlegmatizer, by mass).
- Nitroglycerin, solution in alcohol, (with more than 1 % but not more than 10 % nitro-glycerin).
- Nitro-guanidine (or) Picrite, (dry or wetted with less than 20 % water, by mass).
- Nitroso guanidine.
- Nitro starch, (dry or wetted with less than 20 % water, by mass).
- Nitrotriazolone (or) NTO.
- Octolite (or) Octol, (dry or wetted with less than 15 % water, by mass).
- Penta-erythrite tetra-nitrate (or) Penta-erythritol tetra-nitrate (or) PETN, wetted (with not less than 25 % water, by mass (or) Penta-erythrite tetra-nitrate (or) Penta-erythritol tetra-nitrate (or) PETN, desensitized (with not less than 15% Phlegmatizer).
- Penta-erythrite tetra-nitrate (or) Penta-erythritol tetra-nitrate (or) PETN (with not less than 7 % wax by mass).
- Pentolite, (dry or wetted with less than 15 % water, by mass).
- Potassium salts of aromatic nitro-derivatives, explosive.
- RDX and HMX mixtures, wetted (with not less than 15 % water by mass) (or) RDX and HMX mixtures, desensitized (with not less than 10 % phlegmatizer by mass).
- Sodium dinitro-o-cresolate, (dry or wetted with less than 15 % water, by mass).
- Sodium picramate, (dry or wetted with less than 20 % water, by mass).
- Sodium salts of aromatic nitro-derivatives, explosive.
- Tetra-nitro-aniline.
- Tetrazol-1-acetic acid.
- Tri-nitro-meta-cresol.
- Tri-nitro-aniline (or) Picramide.
- Tri-nitroanisole.
- Tri-nitrobenzene, (dry or wetted with less than 30 % water, by mass).
- Tri-nitrobenzene sulfonic acid.
- Tri-nitro-benzoic acid, (dry or wetted with less than 30 % water, by mass).
- Tri-nitro-chloro benzene (or) Picryl chloride.
- Tri-nitro-fluorenone.

- Tri-nitro-naphthalene.
- Tri-nitro-phenetole.
- Tri-nitro-phenol (or) Picric acid, (dry or wetted with less than 30 % water, by mass).
- Tri-nitro-phenyl methyl nitramine (or) Tetryl
- Tri-nitro-resorcinol (or) Styphnic acid, (dry or wetted with less than 20 % water, or mixture of alcohol and water, by mass).
- Trinitrotoluene and Tri-nitrobenzene mixtures (or) Trinitrotoluene (or) TNT and tri-nitrobenzene mixtures (or) TNT.
- and hexa-nitro-stilbene mixtures and Hexa-nitro-stilbene mixtures.
- Trinitrotoluene mixtures containing Tri-nitrobenzene and Hexa-nitro-stilbene (or) TNT mixtures containing tri-nitrobenzene and hexa-nitro-stilbene.
- Trinitrotoluene (or) TNT, (dry or wetted with less than 30 % water, by mass)
- Tritonal.
- Urea nitrate, (dry or wetted with less than 20 % water, by mass).
- Zirconium picramate, (dry or wetted with less than 20 % water, by mass).

Appendix II: Lecture on Bottles and Cylinders

Combustible liquid

Tetra-phenyl silane

Corrosive

Antimony pentachloride

Antimony penta-fluoride

Antimony tri-bromide

Antimony tri-chloride

Antimony trifluoride

Boron tri-bromide

Bromine

Hydro-iodic acid

Hydrogen fluoride

Hydrogen iodide

Molybdenum hexafluoride

Oleum

Silicon tetra-bromide

Silicon tetrachloride

Sulfur di-bromide

Sulfur dichloride

Sulfur mono-bromide

Sulfur mono-chloride

Sulfur oxide

Sulfur trioxide

Sulfuric acid

Sulfuryl chloride

Flammable Gas

Acetyl fluoride

Acetylene

Butadiene

Butane

Butene

Carbon monoxide

Deuterium

Ethane

Ethylene

Hydrogen

Hydrogen sulfide

Isobutane

Isobutylene

Mapp gas (Welding Gas)

Methane

Methyl acetylene

Methyl silane

Propane

Propylene

Silane

Tetra-methyl silane

Tri-chloro-silane

Tri-methyl borane

Trimethyl chloro-silane

Trimethyl ethoxy silane

Tetra-chloro silane

Thionyl bromide

Thionyl chloride

Titanium tetra-bromide

Titanium tetrachloride

Tri-chloro n-decyl silane

Tri-chloro-acetyl chloride

Tri-chloromethane sulfonyl chloride

Tri-chloro-phenyl silane

Tri-fluoro-acetyl fluoride

Tungsten bromide

Tungsten chloride

Tungsten fluoride

Tungsten hexafluoride

Vanadium oxy-tri-chloride

Vanadium tetrachloride

Oxidizer

Oxygen

Poison

Antimony tri-iodide

Boron tri-chloride

Boron trifluoride

Bromine chloride

Cyanogen bromide

Cyanogen chloride

Trimethyl silane

Nonflammable gas

Ammonia

Argon

Carbon dioxide

Chlorine

Deuterium bromide

Deuterium chloride

Deuterium fluoride

Deuterium iodide

Helium

Krypton

Neon

Nitrogen

Nitrous oxide

Ozone

Phosphorus trifluoride

Tetra-fluoro silane

Xenon

Hydrogen bromide
Hydrogen chloride
Nitric oxide
Nitrogen dioxide
Nitrogen oxide
Nitrogen trioxide
Phosphorus penta-fluoride
Silicon tetrafluoride
Sulfur dioxide
Sulfur tetrafluoride

Appendix III: Definition of Hazardous Waste

In addition to a number of "listed" solvents, acutely hazardous, and extremely hazardous substances, chemical wastes may be regulated as hazardous by the Environmental Protection Agency if they exhibit any of the following characteristics:

Ignitability

A waste exhibits the characteristic of Ignitability if a representative sample of the waste has any of the following properties:

- It is a liquid, other than an aqueous solution containing less than 24 % alcohol by volume, and has flash point less than 60°C (140°F), as determined by a Pensky-Martens Closed Cup Tester or a Setaflash Closed Cup Tester, or as determined by an equivalent test method approved by the EPA.
- It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture, or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that it creates a hazard.
- It is an ignitable compressed gas.
- It is an oxidizer.

Corrosivity

A waste exhibits the characteristic of corrosivity if a representative sample of the waste has either of the following properties:

- It is aqueous and has a pH less than or equal to 2, or greater than or equal to 12.5, as determined by a pH meter using either an EPA test method or an equivalent test method approved by the EPA.
- It is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55°C (130°F), or in an equivalent test method approved by the EPA.

Reactivity

A waste exhibits the characteristic of reactivity if a representative sample of the waste has any of the following properties:

- It is normally unstable and readily undergoes violent change without detonating, e.g. explosive polymerization.
- It reacts violently with water.
- It forms potentially explosive mixtures with water.
- When mixed with water, it generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
- It is a cyanide or sulfide bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
- It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.
- It is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.
- It is a forbidden explosive, a Class A explosive, or a Class B explosive.

Toxicity

A waste exhibits the characteristic of toxicity if a representative sample of the waste has any of the following properties:

- Any chemical at the right dose could be toxic to humans. However, there are some chemicals that are known to be hazardous at very low concentrations, over a very short exposure time, or after repeated exposures. These chemicals are the toxins, poisons, and carcinogens.
- A toxin may be mutagenic and cause a heritable change in the gene structure or may also be teratogenic and cause a malformation of an embryo. Pregnant women and persons in their childbearing years should not work with or, at a minimum, use extreme caution while handling these materials.
- The toxicity of a material is due to its ability to interfere with the metabolism of living tissue. An acute toxin can cause an adverse effect after a single or short duration exposure. A chronic toxin causes an adverse effect after repeated exposures, after a long duration single exposure, or after a long latency period. Carcinogens are examples of chronic toxins that have a long latency period before the effects of the exposure are observed.
- See Table I for a list of toxic substances.

Table I. Toxicity characteristic constituents

Arsenic	1,4-Dichlorobenzene	Methoxy chlor (insecticide)
Barium	1,2-Dichloroethane	Methyl ethyl ketone
Benzene	1,1-Dichloroethylene	Nitrobenzene
Cadmium Carbon tetrachloride	2,4-Dinitrotoluene	Pentachlorophenol
Chlordane	Endrin 72-20-8	Pyridine
Chlorobenzene	Heptachlor (and its epoxide)	Selenium
Chloroform	Hexa-chloro-benzene	Silver
Chromium	Hexa-chloro-butadiene	Tetra-chloro ethylene
o-Cresol	Hexa-chloro-ethane	Toxaphene (insecticide)
m-Cresol	Lead	Trichloroethylene
p-Cresol	Lindane	2,4,5-Trichlorophenol
Cresol	Mercury	2,4,6-Trichlorophenol
2, 4-D		2,4,5-TP (Silvex)
		Vinyl chloride

Toxicity: A waste exhibits the characteristic of toxicity if the extract from a representative sample of the waste contains any of the contaminants listed in Table I above at a concentration equal to or greater than the respective regulatory level. Where the waste contains less than 0.5 % filterable solids, the waste itself, after filtering, is considered to be the extract for the purposes of this section.

Appendix IV: Hazards Rating

GUIDE TO HAZARD INFORMATION – (A)

Compound	H	F	R	S/N	Compound	H	F	R	S/N
Acetal	2	3	0		Ammonium dichromate	2	1	1	OX
Acetaldehyde	3	4	2		Ammonium Fluoride	3	0	0	
Acetanilide	3	1	0		Ammonium Nitrate	0	0	3	OX
Acetic Acid (glacial)	3	2	0		Ammonium Perchlorate	1	0	4	OX
Acetic Anhydride	3	2	1	W	Ammonium Permanganate	0	0	3	OX
Acetoacetanilide	2	1	0		Ammonium Sulfate	3	0	0	
Acetoacet-ortho-toluidide	2	1	1		Amyl Acetate	1	3	0	
Acetoacet-para-phenetide	2	1	1		Amyl Alcohol	1	3	0	
Acetone	1	3	0		Amylamine	2	3	0	
Acetone cyanohydrin	4	2	2		Amyl bromide	1	3	0	
Acetonitrile	2	3	0		Amyl benzene	1	2	0	
Acetonylacetone	1	1	0		Amyl butyrate	1	2	0	
Acetophenone	1	2	0		Amyl Chloride	1	3	0	
Acetyl Chloride	3	3	2	W	Amyl cyclohexane	1	-	0	
Acetylene	0	4	3		Amyl Ether	1	2	0	
Acetyl Peroxide.	1	2	4		Amyl formate	1	3	0	
Acrolein	4	3	3		Amyl lactate	1	2	0	
Acrolein Dimer	1	2	1		Amyl laurate	0	1	0	
Acrylamide	2	2	2		Amyl Maleate	0	1	0	
Acrylic Acid (glacial)	3	2	2		Amyl mercaptan	2	3	-	
Acrylonitrile	4	3	2		Amyl naphthalene	0	1	0	
Adipic Acid	-	1	0		Amyl nitrate	2	2	0	OX
Adiponitrile	2	2	1		Amyl nitrite	1	-	2	
Adipoyl chloride	2	2	0		Amyl oleate	0	1	0	

Adipyldinitrile	4	2	-		Amyl oxalate	0	1	0	
Aldol	3	2	2		o-Amyl Phenol	2	1	0	
Allyl Acetate	1	3	0		Amyl phenyl ether	0	2	0	
Allyl Alcohol	4	3	1		Amyl Propionate	0	2	0	
Allylamine	4	3	1		Amyl salicylate	0	1	0	
Allyl Bromide	3	3	1		Amyl Stearate	0	1	0	
Allyl caproate	1	2	0		Amyl sulfides (mixed)	2	2	0	
Allyl Chloride	3	3	1		Amyl Toluene.	2	2	0	
Allyl Chloroformate	3	3	1		Amyl trichlorosilane	3	2	2	W
Allyl ether	3	3	2		Amyl xylyl ether	2	1	0	
Allylidene diacetate	2	2	1		Aniline	3	2	0	
Allyl trichlorosilane	3	3	2	W	Aniline Hydrochloride	3	1	-	
Alpha, beta-dichlorostyrene	2	1	2		2-Anilinoethanol	2	1	0	
Alpha, beta-glycerin dichlorohydrin	2	1	0		o-Anisidine	2	1	0	
Alpha-butylene glycol	0	2	-		Anisole	1	2	0	
Adipyldinitrile	4	2	-		Anthracene	0	1	-	
Alpha-chloropropionic acid	-	1	0		Anthraquinone	0	1	-	
Alpha-methylbenzyl dimethyl amine	2	2	0		Antimony Pentachloride, liquid	3	0	1	
Alpha-methylbenzyl ether	2	1	0		Antimony Pentafluoride	4	0	1	
Alpha-methylbenzylamine	2	2	0		Antimony Pentasulfide	3	1	1	
Alpha-methyl styrene	1	2	1		Antimony sulfide	1	1	1	
Alpha-pinene	1	3	0		Arsenic Chloride	3	0	0	
Aluminum (dust or powder)	0	1	1		Arsenic pentafluoride	4	0	1	
Aluminum alkyls	3	4	3	W	Arsenic pentoxide	3	0	0	
Aluminum chloride (anhydrous)	3	0	2	W	Arsenic trichloride	3	0	0	
Aluminum phosphide	4	4	2	W	Arsenic trioxide	3	0	0	

Aluminum (uncoated)	0	3	1		Arsenic Trisulfide	3	0	0	
2-Amino-1-butanol	2	2	0		Arsine	4	4	2	
(2-Aminoethyl) ethanolamine	2	1	0		Asphalt (cutback)	0	3	0	
4-(2-Aminoethyl)-morpholine	2	2	0		Asphalt (typical)	0	1	0	
2-Amino-2-methyl-1-propanol	2	2	0		Asphalt, liquid-medium curing	0	2	0	
1-Amino-2-propanol	2	2	0		Asphalt, liquid-rapid curing	0	3	0	
3-Aminopropanol	3	2	0		Asphalt, liquid-slow curing (grade sc-250)	0	2	0	
Ammonia, Anhydrous	3	1	0		Azobisisobutyronitrile	3	-	2	

GUIDE TO HAZARD INFORMATION – (B)

Compound	H	F	R	S/N	Compound	H	F	R	S/N
Barium Chlorate	2	0	1	OX	1,3-Butadiene	2	4	2	
Barium Nitrate	1	0	0	OX	Butadiene Monoxide	2	3	2	
Barium Peroxide	1	0	0	OX	Butane	1	4	0	
Benzaldehyde	2	2	0		1,3-Butanediamine	3	2	0	
Benzedrine	0	1	-		1,2-Butanediol	1	2	0	
Benzene	2	3	0		1,4-Butanediol	1	1	0	
Benzoic Acid	2	1	-		2,3-Butanediol	1	1	0	
Benzol (diluent)	2	3	0		2,3-Butanedione	1	3	0	
Benzo trichloride	3	1	0		1-Butanethiol	2	3	0	
Benzo trifluoride	3	3	1		2-Butanethiol	2	3	0	
Benzoyl Chloride	3	2	2	W	1-Butene	1	4	0	
Benzyl Acetate	1	1	0		2-Butene-cis.	1	4	0	
Benzyl Alcohol	2	1	0		2-Butene-trans	1	4	0	
Benzile benzoate	1	1	0		Butenediol	1	1	0	
Benzyl butylphthalate	1	1	0		Butyl Acetate	1	3	0	

Benzyl chloride	3	2	1		Butyl Acetoacetate	1	2	0	
Benzyl Cyanide	2	1	0		Butyl acetyl ricinoleate	2	1	0	
Benzyl mercaptan	2	2	-		Butyl Acrylate	2	2	2	W
Benzyl Salicylate	1	1	0		Butyl Alcohol	1	3	0	
Beryllium (dust or powder)	3	1	0		Butylamine	3	3	0	
Beta-amylene-cis	0	4	-		Butylamine Oleate	3	2	0	
Beta-amylene-trans	0	4	-		Butylbenzene	2	2	0	
2,Beta-butoxyethoxyethyl chloride	2	2	0		Butyl Benzoate	1	1	0	
Beta-butoxyethoxyethyl salicylate	2	2	0		2-Butylbiphenyl	0	1	-	
Beta-butylene glycol	1	1	0		Butyl Bromide	2	3	0	
Beta-chloro phenetole	-	1	0		Butyl butyrate	2	2	0	
Beta-methyl mercaptopropionaldehyde	-	2	0		Butyl Chloride	2	3	0	
Beta-naphthol	-	1	0		Butyl cyclohexane	0	-	0	
Beta-phellandrene	0	2	0		Butyl cyclopentane	0	-	0	
Beta-propiolactone	0	2	0		Butyldecalin	1	1	0	
Beta-(p-tert-butyl phenoxy) ethanol	0	1	0		Butylene glycol (pseudo)	0	2	-	
Bicyclohexyl	1	2	0		Butyl glycolate	0	2	-	
Biphenyl	2	1	0		Butyl isovalerate	0	-	-	
2-Biphenylamine	2	1	0		2-Butyloctanol	1	1	0	
Bis (2-chloroethyl) ether	3	2	1		2,3-Butylene oxide	2	3	2	
Bis (2-chloroethyl) formal	2	1	0		Butyl Formate	2	3	0	
Bis-diethylene glycol monoethyl ether phthalate	1	1	0		N-Butyl Isocyanate	3	2	2	
Bis (2,4-dimethylbutyl) maleate	1	1	0		Butyl Isovalerate	0	-	-	
Bis (2-ethylhexyl) amine	3	1	0		Butyl Lactate	1	2	0	
Bis (2-ethylhexyl)-ethanolamine	1	1	0		Butyllithium	3	4	2	W
Bis (2-ethylhexyl) maleate	0	1	0		Butyl Methacrylate	2	2	0	
Bis (2-ethylhexyl) succinate	0	1	0		Butyl Naphthalene	1	1	0	

Bis (p-tert-butylphenyl) phenyl phosphate	-	1	0		Butyl Nitrate	1	3	3	
Bis (2,2,4-trimethyl-pentanediolisobutyrate) diglycolate	0	1	0		Butyl Oxalate	0	1	0	
Borneol	2	2	0		Butyl phosphate	3	1	-	
Boron oleate	0	1	1		Boron phthalyl butyl glycolate	1	1	0	
Boron phenyl ether	1	2	0		Butyl Propionate	2	3	0	
Boron tribromide	3	0	2	W	Butyl ricinoleate	1	1	0	
Boron Trifluoride	4	0	1		Butyl sebacate	1	1	0	
Boron Trifluoride etherate	3	2	1	W	Butyl Stearate	1	1	0	
Bromine	3	0	0	OX	Butyl Trichlorosilane	2	2	0	
Bromine pentafluoride	4	0	3	W	2-Butyne	-	4	-	
Bromine Trifluoride	4	0	3	W, OX	Butyraldehyde	3	3	2	
Bromobenzene	2	2	0		Butyraldol	2	2	0	
4-Bromodiphenyl	2	1	0		Butyraldoxime	2	2	0	
o-Bromo toluene	2	2	0		Butyric Acid	3	2	0	
Butyrolactone	0	1	0		Butyric anhydride	1	2	1	W

GUIDE TO HAZARD INFORMATION – I

Compound	**H**	**F**	R	**S/N**	**Compound**	**H**	**F**	**R**	**S/N**
Calcium	3	1	2	W	Citral	0	2	0	
Calcium Carbide	3	3	2	W	Citronellal	0	2	0	
Calcium Chlorate	2	0	2	OX	Citronellol	0	1	0	
Calcium Cyanide	3	0	1		Cleaning solvent, Stoddard solvent	0	2	0	
Calcium Hypochlorite	3	0	1	OX	Cleaning solvents, 140(60) class	0	2	0	

Calcium Oxide	3	0	1		Coal tar light oil	2	3	0	
Camphor	0	2	0		Coal tar pitch	0	1	0	
Camphor oil (light)	2	2	0		Cobalt Naphtha	1	2	0	
Caproic Acid	2	1	0		Coconut Oil	0	1	0	
Capryl aldehyde	2	2	0		Cod Liver Oil	0	1	0	
Capryl Chloride	3	2	1		Collodion	1	4	0	
Carbon Disulfide	3	4	0		Corn Oil	0	1	0	
Carbon Monoxide	3	4	0		Cottonseed oil refined	0	1	0	
Carbon oxysulfide	3	4	1		Creosote Oil	2	2	0	
Carnauba wax	0	1	0		o-Cresol	3	2	0	
Caron Tetrachloride	3	0	0		Cresyl diphenyl phosphate	0	1	0	
Castor Oil	0	1	0		Crotonaldehyde	4	3	2	
Cellulose nitrate wet with alcohol	2	3	3		Crotonic Acid	3	2	0	
Chlorine	4	0	0	OX	Crotononitrile	-	1	0	
Chlorine Monoxide	3	4	3		Crotonyl alcohol	-	3	2	
Chlorine trifluoride	4	0	3	W, OX	1-Crotyl bromide	2	3	2	
Chloroacetic Acid	3	1	0		1-Crotyl chloride	2	3	2	
Chloroacetonitrile	3	2	0		Cumene	2	3	1	
Chloroacetophenone	2	1	0		Cumene hydroperoxide	1	2	4	OX
Chloroacetyl chloride	3	0	1		Cupric Nitrate	1	0	0	OX
Chlorobenzene	2	3	0		Cyanamide	4	1	3	
Chlorobenzotrifluoride	-	2	0		Cyanoacetic acid	3	1	0	
2-Chloro-1,3-butadiene	2	3	0		2-Cyanoethyl acrylate	2	1	1	
2-Chlorobutene-2	2	3	0		Cyanogen	4	4	2	
Chlorodiethyl silane	3	3	1		Cyanogen Bromide	4	0	1	
Chlorodinitrobenzenes	3	1	4		Cyclamen aldehyde	-	2	0	
2-Chloro-4,6-di-tert-amylphenol	2	1	0		Cyclobutane	1	4	0	

2-Chloroethanol	4	2	0		1,5,9-Cyclododecatriene	-	2	0	
Chloroethyl acetate	2	2	0		Cycloheptane	0	3	0	
2-Chloroethyl acetate	2	2	0		Cyclohexane	1	3	0	
Chloro-4-ethylbenzene	1	2	0		1,4-Cyclohexane dimethanol	-	1	0	
2-Chloroethyl-2-xenyl ether	-	1	0		Cyclohexanethiol	-	2	0	
Chloroform	2	0	0		Cyclohexanol	1	2	0	
1-Chlorohexane	-	3	0		Cyclohexanone	1	2	0	
1-Chloronapthalene	1	1	0		Cyclohexene	1	3	0	
2-Chloro-5-nitrobenzotrifluoride	-	1	3		Cyclohexenone	1	3	0	
1-Chloro-1-nitroethane	-	2	3		Cyclohexyl acetate	1	2	0	
1-Chloro-1-nitropropane	-	2	3		Cyclohexylamine	3	3	0	
2-Chloro-2-nitropropane	-	2	3		Cyclohexylbenzene	2	1	0	
2-Chloro-4-phenylphenol	2	1	0		Cyclohexyl Chloride	2	3	0	
1-Chloro-2-propanol	2	2	0		1-Cyclohexylcyclohexanol	0	1	0	
2-Chloro-1-propanol	2	2	0		Cyclohexyl formate	-	2	0	
1-Chloropropylene	2	4	2		Cyclohexyl trichlorosilane	2	2	1	
Chloropicrin	4	0	3		1,5-Cyclooctadiene	-	3	0	
Chlorosilanes, N.O.S.	3	3	2	W	Cyclopentane	1	3	0	
Chloro sulfonic acid	4	0	2	W, OX	Cyclopentanol	0	2	0	
2-Chloro propylene	2	4	0		Cyclopentanone	2	3	0	
Chloro-4-tert-amylphenol	2	1	0		Cyclopentene	1	3	1	
2-Chloro-4-tert-amylphenyl methyl ether	1	1	0		Cyclopentanone	2	3	0	
Chlorotoluene	2	2	0		Cyclopropane	1	4		
Chromic Acid	3	0	1	OX	Chromyl chloride	3	0	2	W

GUIDE TO HAZARD INFORMATION – (D)
(Decaborane – Diethylene glycol phthalate)

Compound	H	F	R	S/N	Compound	H	F	R	S/N
Decaborane	3	2	1		1,2-Dichloroethylene	2	3	2	
Decahydronaphthalene	2	2	0		2,2-Dichloroethyl ether	3	2	1	
Decahydronaphthalene-trans	0	2	0		1,3-Dicholoro-2,4-hexadiene	-	2	0	
Decane	0	2	0		Dichloroisopropyl ether	2	2	0	
Decanol	0	2	0		2,2-Dichloro isopropyl ether	2	2	0	
1-Decene	0	2	0		1,1-Dichloro-1-nitro ethane	2	2	3	
Decyl acrylate	2	1	0		1,1-Dichloro-1-nitro propane	2	2	3	
Decyl amine	2	1	0		1,5-Dicholoropentane	2	3	0	
Decyl benzene	2	1	0		Dichloropentanes	2	2	0	
Decyl naphthalene	1	1	0		1,3-Dicholoro-2-propanol	2	2	0	
Decyl nitrate	-	1	0		1,3-Dichloropropene	2	3	0	
Dehydroacetic acid	1	1	0		2,3-Dichloropropene	3	3	0	
Denatured alcohol	0	3	0		2,4-Dichlorophenol	-	1	0	
Deuterium	0	4	0		Dichlorosilane	3	4	2	W
Diacetone Alcohol	1	2	0		Dicyclohexylamine	3	1	0	
Diallyl phthalate	2	1	0		Dicyclopentadiene	1	3	1	
1,3-Diamino-2-propanol	2	1	0		Didecyl Ether	0	1	0	
Diamylamine	3	2	0		Diesel Fuel Oil No. 1	0	2	0	
Diamylbenzene	0	1	0		Diethanolamine	1	1	0	
Diamylbiphenyl	0	1	0		Diethyl acetoacetate	2	2	0	
Diamylene	0	2	0		Diethyl aluminum chloride	3	4	3	W
Diamyl maleate	0	1	0		Diethyl aluminum hydride	-	3	3	W
Diamyl naphthalene	0	1	0		Diethylamine	3	3	0	
2,4-Diamylphenol	2	1	0		2-(Diethylamino) ethanol	2	2	0	

Diamyl phthalate	0	1	0		3-(Diethylamino)-propylamine	2	2	0	
Diamyl Sulfide	2	2	0		Di-2-ethylbutylphthalate	0	1	0	
Dibenzoyl Peroxide	1	4	4	OX	Diethyl carbamoyl chloride	2	1	2	W
Dibenzyl ether	0	1	0		Diethyl carbonate	2	3	1	
Diborane	4	4	3	W	Diethyl cyclohexane	2	2	0	
Dibutoxyethylphthalate	0	1	0		1,3-Diethyl-1,3-diphenyl urea	1	1	0	
Dibutoxymethane	0	2	0		Diethyl fumarate	1	1	0	
Dibutoxytetraglycol	2	1	0		Diethylene glycol	1	1	0	
Dibutyl amine	3	2	0		Diethylene glycol bis(allyl carbonate)	1	1	0	
Dibutylaminoethanol	3	2	0		Diethylene glycol bis(2-butyoxyethyl carbonate)	1	1	1	
Dibutyl Ether	2	3	1		Diethylene glycol bis (butyl carbonate)	1	1	1	
Dibutyl isophthalate	0	1	0		Diethylene glycol bis (phenyl carbonate)	0	1	1	
Dibutyl isopropanol amine	2	1	0		Diethylene glycol butyl ether acetate	-	1	0	
Dibutyl maleate	1	1	0		Diethylene glycol diacetate	1	1	0	
Dibutyl Oxalate	0	1	0		Diethylene glycol dibenzoate	0	1	0	
Dibutyl Phosphite	3	2	0		Diethylene glycol dibutyl ether	1	1	0	
Dibutyl Phthalate	0	1	0		Diethylene glycol diethyl ether	1	2	0	
Dibutyl Sebacate	0	1	0		Diethylene glycol diethyl levulinate	0	1	0	
Dicapryl phthalate	0	1	0		Diethylene glycol dimethyl ether	1	2	1	
Dichloroacetyl chloride	3	2	2	W	Diethylene glycol dipropionate	1	1	0	
3,4-Dichloroaniline	3	1	0		Diethylene glycol ethyl ether	1	1	0	
o-Dichlorobenzene	2	2	0		Diethylene glycol ethyl ether phthalate	0	1	0	
2,3-Dichlorobutadiene-1,3	3	3	2		Diethylene glycol methyl ether	2	2	0	
1,2-Dichlorobutane	2	2	0		Diethylene glycol methyl ether acetate	0	2	0	

2,3-Dichlorobutane	2	2	0		Diethylene glycol monobutyl ether	1	2	0	
1,4-Dichlorobutane	3	2	0		Diethylene glycol monobutyl ether acetate	1	1	0	
1,3-Dichlorobutene-2	2	3	0		Diethylene glycol monoethyl ether	1	1	0	
1,3-Dicholoro-2-butene	3	3	2		Diethylene glycol monoethyl ether acetate	1	1	0	
3,4-Dichlorobutene-1	3	2	1		Diethylene glycol monois butyl ether	1	1	0	
Dichlorodimethyl ether, symmetrical	4	3	1		Diethylene glycol monomethyl ether	1	1	0	
1,1-Dichloroethene	2	4	2		Diethylene glycol monomethyl ether formal	1	1	0	
1,2-Dicholoroethyl ether	3	2	1		Diethylene glycol n-butyl ether	1	1	0	

GUIDE TO HAZARD INFORMATION – (D…)
(Diethyl triamine – Dypnone)

Compound	**H**	**F**	**R**	**S/N**	**Compound**	**H**	**F**	**R**	**S/N**
Diethylene Triamine	**3**	**1**	**0**		2,3-Dimethyloctane	**0**	**2**	**0**	
Di-2-ethylhexyl adipate	**0**	**1**	**0**		3,4-Dimethyloctane	**0**	**2**	**0**	
Diethyl Ketone	**1**	**3**	**0**		Dimethyl-o,o-dichlorovinyl-2,2-phosphate (technical)	**3**	**1**	**-**	
Diethyl maleate	**1**	**1**	**0**		2,3-Dimethylpentane	**0**	**3**	**0**	
Diethyl malonate	**0**	**1**	**0**		2,4-Dimethylpentane	**0**	**3**	**0**	
3,3-Diethylpentane	**0**	**3**	**0**		2,4-Dimethyl-3-pentanol	**0**	**2**	**0**	
Diethyl peroxide	**-**	**4**	**4**		2,3-Dimethylpentaldehyde	**1**	**3**	**0**	
Diethyl phthalate	**0**	**1**	**0**		Dimethyl Phthalate	**0**	**1**	**0**	
2,2-Diethyl-1,3-propanediol	**2**	**1**	**0**		Dimethyl piperazine-cis	**2**	**2**	**0**	
Diethyl selenide	**2**	**-**	**0**		2,2-Dimethylpropane	**0**	**4**	**0**	
Diethyl sulfate	**3**	**1**	**0**		2,5-Dimethylpyrazine	**-**	**2**	**0**	
Diethyl Succinate	**1**	**1**	**0**		Dimethyl sebacate	**0**	**1**	**0**	

Diethyl Sulfate	3	1	1		Dimethyl Sulfate	4	2	0	
Diethyl tartrate	0	1	0		Dimethyl Sulfide	1	4	0	
Diethyl telluride	1	4	3	W	Dimethyl Sulfoxide	1	1	0	
Diethyl terephthalate	0	1	0		Dimethyl terephthalate	1	1	0	
Diethylzinc	3	4	3	W	2,4-Dinitroanaline	3	1	3	
Dihexylamine	2	1	0		Dinitrobenzene (ortho)	3	1	4	
Diisobutyl aluminum hydride	-	3	3	W	1,2-Dinitrobenzene	3	1	4	
Diisobutyl Amine	3	3	0		1,2-Dinitrobenzol	3	1	4	
Diisobutyl Carbinol	1	2	0		Dinitrochlorobenzene	3	1	4	
Diisobutylene	1	3	0		2,4-Dinitrotoluene	3	1	3	
Diisobutyl Ketone	1	2	0		2,5-Dinitrotoluene	3	1	3	
Diisodecyl adipate	0	1	0		2,6-Dinitrotoluene	3	1	3	
Diisodecyl phthalate	0	1	0		Dioctyl adipate	0	1	0	
Diisooctyl Phthalate	0	1	0		Dioctyl azelate	0	1	0	
Diisopropanol amine	2	1	0		Dioctyl Ether	0	1	0	
Diisopropyl amine	3	3	0		Dioctyl phthalate	0	1	0	
Diisopropyl Benzene	0	2	0		p-Dioxane	2	3	1	
Diisopropyl maleate	1	1	0		Di(o-xenyl) phenyl phosphate	0	1	0	
Diisopropyl peroxy dicarbonate	0	4	4	OX	Dioxolane	2	3	2	
Diketene	4	2	2		Dipentene	0	2	0	
2,5-Dimethoxyaniline	2	1	0		Diphenylamine	3	1	0	
2,5-Dimethoxychlorobenzene	2	1	0		1,1-Diphenylbutane	0	1	0	
Dimethoxy ethyl phthalate	0	1	0		Diphenyldichlorosilane	3	1	0	
Dimethoxy tetra glycol	1	1	0		Diphenyldodecyl phosphite	0	1	0	
Dimethylacetamide	2	2	0		1,1-Diphenylethane	0	1	0	
Dimethylamine	3	4	0		1,2-Diphenylethane	0	1	0	
Dimethyl anthranilate	1	2	0		Diphenylmethane	1	1	0	

2-(Dimethylamino) ethyl methacrylate	2	2	0		Diphenyl (o-xenyl) phosphate	0	1	0	
3-(Dimethylamino)-propionitrile	-	2	1		Diphenyl oxide	1	1	0	
3-(Dimethylamino)-propylamine	3	2	0		1,1-Diphenylpentane	0	1	0	
N, N-Dimethylaniline	3	2	0		Diphenyl Phthalate	0	1	0	
Dimethyl benzyl carbinyl acetate	1	1	0		1,1-Diphenypropane	0	1	0	
2,2-Dimethylbutane	1	3	0		Dipropyl aluminum hydride	-	3	3	W
2,3-Dimethylbutane	1	3	0		Dipropyl amine	3	3	0	
2,3-Dimethyl-1-butene	0	3	0		Dipropylene glycol	0	1	0	
2,3-Dimethyl-2-butene	0	3	0		Dipropylene glycol methyl ether	0	2	0	
1,3-Dimethylbutyl acetate	1	2	0		Disecbutyl amine	3	3	0	
1,3-Dimethylbutylamine	2	3	0		Di-tert-amyl cyclohexanol	0	1	0	
Dimethyl chloracetal	2	2	0		Di-tert-amylphenoxy ethanol	0	1	0	
Dimethylcyanamide	4	2	1		2,5-Di-tert-butylhydroquinone	1	1	0	
1,2-Dimethylcyclohexane	0	-	0		Di-tert-butyl-p-cresol	0	1	0	
1,3-Dimethylcyclohexane	0	3	0		Di-tert-butyl peroxide	3	2	4	OX
1,4-Dimethylcyclohexane	1	3	0		Ditridecyl phthalate	0	1	0	
1,3-Dimethylcyclohexane-cis	0	3	0		Divinyl acetylene	-	3	3	
1,3-Dimethylcyclohexane-trans	0	3	0		Divinylbenzene	1	2	2	
Dimethyl decalin	0	2	0		Divinyl Ether	2	4	2	
Dimethyldichlorosiliane	3	3	1		Dodecane	0	2	0	
Dimethyldioxane	2	3	0		1-Dodecanethiol	2	1	0	
1,3-Dimethyl-1,3-diphenylcyclobutane	0	1	0		1-Dodecanol	0	1	0	
2,4-Dimethyl-3-ethylpentane	0	3	0		4-Dodecycloxy-2-hydroxy-benzophenone	-	1	0	
N, N-Dimethylformamide	1	2	0		Dodecyl benzene (crude)	1	1	0	

2,5-Dimethylfuran	2	3	0		Dodecylene	0	1	0	
Dimethyl glycol phthalate	0	1	0		Dodecyl phenol	0	1	0	
3,3-Dimethylheptane	0	3	0		Dypnone	1	1		
2,3-Dimethylhexane	0	3	0		Dimethyl Maleate	1	1	0	
2,4-Dimethylhexane	0	3	0		2,6-Dimethylmorpholine	2	2	0	
Dimethyl hexynol	0	2	0		1,1-Dimethylhydrazine	4	3	1	

GUIDE TO HAZARD INFORMATION – (E – G)

Compound	H	F	R	S/N	Compound	H	F	R	S/N
Eicosane	-	1	0		2-Ethylisohexanol	1	2	-	
Endo-tetrahydrodicyclopentadiene	-	-	0		Ethylene Oxide	3	4	3	
Endrin (dry)	2	0	0		Ethyl lactate	2	2	0	
Epichlorohydrin	3	2	2		Ethyl Mercaptan	2	4	0	
Ethane	1	4	0		Ethylene Oxide	3	4	3	
Ethanediol diformate	1	2	0		Ethyl methacrylate	2	3	0	
Ethanolamine	3	2	0		7-Ethyl-2-methyl-4-hendecanol	0	1	0	
Ethoxyacetylene	2	3	1		4-Ethylmorpholine	2	3	0	
Ethoxy benzene	0	2	0		1-Ehtylnapthalene	0	1	0	
2-Ethoxy-3,4-dihydro-2-pyran	2	2	1		Ethyl Nitrate	2	3	4	
2-Ethoxyethyl acetate	2	2	0		Ethyl Nitrite	3	4	4	
3-Ethoxypropanal	2	2	0		3-Ethyloctane	0	2	0	
3-Ethoxypropionaldehyde	2	3	0		4-Ethyloctane	0	2	0	
3-Ethoxypropionic acid	2	1	0		Ethyl Oxalate	0	2	0	
Ethoxytriglycol	0	1	0		Ethyl phenylacetate	0	1	-	
Ethyl abietate	0	1	0		Ethyl phenyl ketone	-	1	0	

Ethyl Acetate	1	3	0		Ethyl phthalyl ethyl glycolate	0	1	0	
Ethyl acetoacetate	2	2	0		Ethyl propenyl ether	2	3	1	
Ethyl acetyl glycolate	0	2	0		Ethyl propyl ether	1	3	0	
Ethyl Acrylate	2	3	2		Ethyl Propionate	-	3	0	
Ethyl Alcohol	0	3	0		2-Ethyl-3-propylacrolein	2	2	1	
Ethyl aluminum dichloride	3	3	3	W	2-Ethyl-3-propylacrylic acid	2	1	1	
Ethyl aluminum sesquichloride	-	3	3	W	Ethyl p-toluene sulfonamide	-	1	0	
Ethylamine	3	4	0		Ethyl p-toluene sulfonate	-	1	0	
Ethyl amino ethanol	-	2	0		Ethyl Silicate	2	2	0	
Ethyl aniline	3	2	0		Ethyl trichloro silane	3	3	2	W
Ethyl aniline	3	2	0		Fish oil	0	1	0	
Ethylbenzene	2	3	0		Fluoboric acid	3	0	0	
Ethyl benzoate	1	1	0		Fluorine	4	0	3	W, OX
Ethyl benzoylacetate	0	1	0		Fluorine, compressed	4	0	4	W
Ethyl benzyl aniline	2	1	0		Fluorobenzene	-	3	0	
Ethyl borate	2	3	0		Formaldehyde	3	4	0	
Ethyl Bromide	2	1	0		Formaldehyde 37%, 15% menthanol	3	2	0	
Ethyl bromoacetate	-	2	0		Formaldehyde 37% menthanol-free	3	2	0	
Ethyl butylamine	3	3	0		Formaldehyde (water solution)	2	2	0	
2-Ethyl-1-butene	0	3	0		Formamide	2	1	0	
3-(2-Ethylbutoxy) propionic acid	2	1	0		Formic Acid	3	2	0	
Ethyl butylamine	3	3	0		Fuel oil no. 1	0	2	0	
ethyl butyl carbonate	2	2	1		Fuel oil no. 2	0	2	0	
ethyl butyl ether	2	3	0		Fuel oil no. 4	0	2	0	
2-Ethyl butyl glycol	0	2	0		Fuel oil no. 5	0	2	0	

ethyl butyl ketone	1	2	0		Fuel oil no. 6	0	2	0	
2-ethyl-2-butyl-1,3-propanediol	2	1	0		Furan	1	4	1	
ethyl butyrate	0	3	0		Furfural	3	2	0	
2-Ethylbutyl acetate	1	2	0		Furfuryl acetate	1	2	1	
2-Ethylbutyl acrylate	2	2	0		Furfuryl Alcohol	1	2	1	
2-Ethylbutyl alcohol	1	2	0		Furfuryl amine	-	3	0	
2-Ethylbutyraldehyde	2	3	1		Gallium arsenide	3	1	2	W
2-Ethylbutyric acid	2	1	0		Gallium phosphide	3	0	1	W
ethyl caproate	2	2	0		Gallium tricholoride	3	0	1	
ethyl caprylate.	2	2	0		Gas, blast furnace	2	4	0	
ethyl chloride	1	4	0		Gas, coal gas	2	4	0	
Ethyl chloroacetate	-	3	0		Gas, coke-oven	2	4	0	
Ethyl cholorformate	4	3	1		Gas, Natural	1	4	0	
Ethyl Crotonate	2	3	0		Gas oil	0	2	0	
Ethyl cyanoacetate	2	1	0		Gas, oil gas	2	4	0	
Ethyl cyclobutane	1	3	0		Gasoline	1	3	0	
Ethyl cyclohexane	1	3	0		Gasoline (100-130 aviation grade)	1	3	0	
Ethyl cyclopentane	1	3	0		Gasoline (115-145 aviation grade)	1	3	0	
Ethyl decanoate	0	1	0		Gasoline (casinghead)	1	4	0	
Ethyl Dichlorosilane	3	3	0		Gasoline 56-100 Octane	1	3	0	
Ethylene	1	4	2		Gas, producer	2	4	0	
Ethylene carbonate	2	1	1		Gas, water	2	4	0	
Ethylene cyanohydrin	1	2	2		Gas, water (carbureted)	2	4	0	
Ethylenediamine	3	2	0		Geraniol	0	1	0	
Ethylene dibromide	3	0	0		Geranyl acetate	0	1	0	
Ethylene Dichloride	2	3	0		Geranyl butyrate	0	1	0	
Ethyl ether	1	4	1		Geranyl formate	0	2	0	

Ethyl Formate	2	3	0		Geranyl propionate	0	1	0	
Ethyl Formate (ortho)	0	3	0		Germane	4	4	3	W
Ethyl fluoride	-	4	0		Glucose Penta propionate	1	1	0	
Ethylene Glycol	1	1	0		Glycerin	1	1	0	
Ethylene Glycol Dibutyl Ether	1	2	0		Glyceryl triacetate	1	1	0	
Ethylene glycol diethyl ether	1	3	0		Glyceryl tributyrate	0	1	0	
Ethylene glycol dimethyl ether	2	2	0		Glyceryl tripropionate	0	1	0	
Ethylene Glycol Ethyl Butyl Ether	1	2	0		Glycidyl Acrylate	0	2	0	
Ethylene glycol ethylhexyl ether	0	1	0		Glycol benzyl ether	0	1	0	
Ethylene glycol isopropyl ether	1	3	0		Glycol diacetate	1	1	0	
Ethylene glycol monoacetate	0	1	0		Glycol dimercapto acetate	2	1		
Ethylene glycol monoacrylate	2	1	1		Ethylene Oxide	3	4	3	
Ethylene glycol monobenzyl ether	2	1	0		Ethylenimine	4	3	3	
Ethylene Glycol Monobutyl Ether	2	2	0		2-Ethylhexanal	2	2	1	
Ethylene Glycol Monobutyl Ether Acetate	1	2	0		2-Ethylhexanol	2	2	0	
Ethylene Glycol Monoethyl ether	2	2	0		2-Ethylhexanoic acid	1	1	0	
Ethylene Glycol Monoethyl ether acetate	1	2	-		2-Ethylhexyl acetate	2	2	0	
Ethylene Glycol Monoisobutyl ether	2	2	-		2-Ethylhexyl acrylate	2	2	0	
Ethylene Glycol Monomethyl ether	2	2	0		2-Ethylhexylamine	2	2	0	
Ethylene Glycol Monomethyl ether acetal	1	2	-		2-Ethylhexyl chloride	2	2	0	
Ethylene Glycol Monomethyl ether acetate	1	2	-		2-Ethylhexyl ether	1	1	0	
Ethylene Glycol Monomethyl ether formal	1	2	-		2-Ethyl-1,3-hexanediol	1	1	0	
Ethylene Glycol n-butyl ether	1	2	0		2-Ethylhexyl acrylate	2	2	2	
Ethylene Glycol phenyl ether	0	1	0		1,1-Ethylidene dichloride	2	3	0	
Ethylenediamine	3	2	0		1,2-Ethylidene dichloride	2	3	0	

GUIDE TO HAZARD INFORMATION – (H – L)

Compound	H	F	R	S/N	Compound	H	F	R	S/N
Hendecane	0	2	0		Isobutyl Acetate	1	3	0	
Heptadecanol	0	1	0		Isobutyl Acrylate	1	3	1	
Heptane	1	3	0		Isobutyl Alcohol	1	3	0	
2-Heptanol	0	2	0		Isobutyl amine	2	3	0	
3-Heptanol	0	2	0		Isobutyl benzene	2	2	0	
4-Heptanone	2	2	0		Isobutyl butyrate	0	2	-	
3-Heptene (mixed cis and trans)	0	3	0		Isobutyl Chloride	2	3	0	
Heptylamine	2	2	0		Isobutyl cyclohexane	0	-	0	
Heptylene	0	3	0		Isobutyl formate	-	3	-	
Heptylene-2-trans	0	3	0		Isobutyl heptyl ketone	2	2	0	
Hexachlorobutadiene	2	1	1		Isobutyl isobutyrate	0	2	0	
Hexachloro diphenyl oxide	2	1	1		Isobutyl Methyl Ketone	2	3	0	
Hexadecane	0	1	0		Isobutyl phenylacetate	0	1	0	
Hexadecylene-1	0	1	0		Isobutyl phosphate	-	1	-	
Hexadecyltrichlorosilane	3	1	0		Isobutyraldehyde	2	3	1	
2,4-Hexadienal	2	2	0		Isobutyric Acid	1	2	0	
1,4-Hexadiene	0	3	0		Isobutyric Anhydride	1	2	1	W
Hexamethyldisilazane	1	3	1		Isobutyronitrile	3	3	0	
Hexanal	2	3	1		Isodecaldehyde	0	2	0	
Hexane	1	3	0		Isodecane	0	2	0	
2,5-Hexanediol	2	1	0		Isodecanoic Acid	0	1	0	
1,2,6-Hexanetriol	1	1	0		Isodecanol, mixed isomers	0	1	0	
3-Hexanone	1	3	0		Isoevgenol	0	1	0	
1-Hexene	1	3	0		Isoheptane	0	3	0	

2-Hexene (mixed cis-and-trans-isomers)	1	3	0		Isoheptane, mixed isomers	1	3	0	
2-Hexene-cis	0	3	0		Isohexane	1	3	0	
3-Hexenol-cis	1	2	0		Isooctane	0	3	0	
Hexyl acetate	1	2	0		Isooctanoic Acid	0	1	0	
Hexyl Alcohol	1	2	0		Isooctenes	0	3	0	
Hexylamine	2	3	0		Isooctyl Alcohol	0	2	0	
Hexyl cinnamic aldehyde	-	1	0		Isooctyl nitrate	-	1	-	
Hexylene glycol	1	1	0		Isopentaldehyde	2	3	0	
Hexyl ether	2	2	0		Isopentane	1	4	0	
Hexyl Methacrylate	0	2	0		Isopentanoic acid	1	-	0	
Hydrazine (Anhydrous)	3	3	3		Isophorone	2	2	0	
Hydrindane	-	-	0		Isophorone diisocyanate	2	1	1	W
Hydriodic acid	3	0	0		Isophthaloyl chloride	-	1	0	
Hydrobromic acid solution	3	0	0		Isoprene	1	4	2	
Hydrocyanic Acid-96%	4	4	2		Isopropenyl acetate	2	3	0	
Hydrogen	0	4	0		3-Isopropoxypropionitrile	1	2	1	
Hydrogen chloride, anhydrous & refrigerated liquid	3	0	1		Isopropyl Acetate	1	3	0	
Hydrogen fluoride, anhydrous	4	0	1		Isopropyl acetylene	2	4	2	
Hydrogen peroxide, aqueous solutions	2	0	1	OX	Isopropyl alcohol	1	3	0	
Hydrogen sulfide	4	4	0		Isopropylamine	3	4	0	
Hydrogen, refrigerated liquid	3	4	0		Isopropyl benzoate	1	1	-	
Hydrochloric Acid	3	0	0		Isopropyl bicyclohexyl	0	1	0	
Hydrobromic Acid	3	0	0		2-Isopropyl biphenyl	0	1	0	
Hydrofluoric Acid	4	0	0		Isopropyl chloride	2	4	0	
Hydroquinone	2	1	0		Isopropyl cyclohexane	1	-	0	
Hydroquinone di-(beta-hydroxyethyl) ether	-	1	0		Isopropyl cyclohexylamine	3	3	0	

Hydroquinone monomethyl ether	-	1	0		Isopropyl Ether	1	3	1	
Hydroxycitronellal	-	1	0		Isopropyl Formate	2	3	0	
2-Hydroxyethyl acrylate	2	1	2		4-Isopropylheptane	0	2	0	
(2-Hydroxyethyl)-ethylenediamine	1	1	0		Isopropyl lactate	2	2	0	
4-(2-Hydroxyethyl) morpholine	2	1	0		Jet Fuels (Jet A and Jet A-1)	0	2	0	
1-(2-Hydroxyethyl) piperazine	0	1	0		Jet Fuels (Jet B)	1	3	0	
Hydroxylamine	2	0	3		Jet Fuels (JP-4)	1	3	0	
Ionone alpha (Alpha-ionone)	-	1	0		Jet Fuels (JP-5)	0	2	0	
Ionone beta (Beta-ionone)	-	1	0		Lactonitrile	4	2	1	
Iron carbonyl	2	3	1	W	Lanolin	0	1	0	
Isano oil	-	1	3		Lard oil (commercial or animal)	0	1	0	
Isoamyl Acetate	1	3	0		Lard oil (pure)	0	1	0	
Isoamyl Alcohol	1	2	0		Lauryl bromide	1	1	0	
Isoamyl butyrate	-	2	-		Lead Arsenates	2	0	0	
Isoamyl chloride	-	3	-		Lead Nitrate	1	0	0	OX
Isobornyl acetate	1	2	0		Lead Thiocyanate	1	1	1	
Isobutane	1	4	0		Linalool (ex Bios de Rose), synthetic	-	2	0	
Lithium Metal	3	2	2	W	Linseed oil, raw	0	1	0	
Lubricating Oil, Mineral	0	1	0		Lithium	1	1	2	W
Lubricating oil, spindle	0	2	0		Lithium aluminum hydride	3	2	2	W
Lubricating oil, turbine	0	1	0		Lithium Hydride	3	2	2	W

GUIDE TO HAZARD INFORMATION – (M)

Compound	**H**	**F**	**R**	**S/N**	**Compound**	**H**	**F**	**R**	**S/N**
acetoacet-m-xylidide	2	1	0		4-Methylcyclohexane	1	3	0	

m- or p-cresol	3	2	0		Methyl cyclohexyl acetate	1	2	0	
m-chloronitrobenzene	3	1	0		Methyl cyclopentane	2	3	0	
m-diethyl benzene	2	2	0		2-Methyldecane	0	2	0	
m-ethyl toluene	-	2	0		Methyl Dichlorosilane	3	3	2	W
m-nitrotoluene	3	1	1		1-Methyl-3,5-diethyl-benzene	0	2	0	
m-terphenyl	0	1	0		Methylene Chloride	2	1	0	
m-tolydiethyanol amine	2	1	0		Methylene dianiline	3	1	0	
m-xylene	2	3	0		Methylene Diisocyanate	1	2	1	W
Magnesium (including all alloys)	0	1	1	W	Methyl Ether	1	4	1	
Magnesium Nitrate	1	0	0	OX	Methyl Ethyl Ether	1	4	1	
Magnesium Perchlorate	1	0	0	OX	2-Methyl-4-ethylhexane	0	3	0	
Maleic Anhydride	3	1	1		3-Methyl-4-ethylhexane	0	3	0	
2-Mercaptoethanol	2	2	-		Methyl Ethyl Ketone	1	3	0	
Menhaden oil	0	1	0		Methyl ethyl ketoxime	-	2	0	
Mercuric Cyanide	3	0	0		2-Methyl-3-ethylpentane	0	3	0	
Mesityl Oxide	2	3	1		2-Methyl-5-ethyl-piperidine	2	2	0	
Metaldehyde	1	3	1		2-Methyl-5-ethylpyridine	3	2	0	
Methacrylic Acid	3	2	2		Methyl Formate	2	4	0	
Methacrylonitrile	2	3	2		2-Methylfuran	2	3	1	
Methallyl alcohol	2	3	0		Methyl Glycol Acetate	1	2	0	
Methallyl chloride	2	3	1		Methyl heptenone	1	2	0	
Methane	1	4	0		Methyl heptadecyl ketone	0	1	0	
Methoxy ethyl phthalate	0	1	0		Methyl heptine carbonate	-	2	0	
Methoxy triglycol	0	1	0		Methyl heptyl ketone	0	2	0	
Methoxy triglycol acetate	0	1	0		Methyl hexyl ketone	0	2	0	
2-Methoxybutanol	1	2	0		2-Methylhexane	0	3	0	

2-Methoxybutyl acetate	1	2	0		3-Methylhexane	0	3	0	
2-Methoxybutyraldehyde	0	2	0		Methyl Hexyl Ketone	0	2	0	
2-Methoxyethyl acrylate	0	2	0		Methylhydrazine	4	3	2	
3-Methoxypropionitrile	4	2	1		Methyl-3-hydroxybutyrate	1	2	0	
3-Methoxypropylamine	2	3	0		Methyl ionone	0	1	0	
Methyl abietate	0	1	0		Methyl Isoamyl Ketone	1	2	0	
Methyl acetate	1	3	0		Methyl Isobutyl Carbinol	2	2	0	
Methyl acetoacetate	2	2	0		Methyl Isobutyl Ketone	2	3	1	
Methyl acrylate	3	3	2		Methyl Isocyanate	4	3	2	W
Methylal	2	3	2		Methyl iso eugenol	0	1	0	
Methyl Alcohol	1	3	0		Methyl isoamyl ketone	1	2	0	
Methyl aluminum sesquibromide	-	3	3	W	Methyl isobutyl carbinol	2	2	0	
Methyl aluminum sesquichloride	-	3	3	W	Methyl isobutyl ketone	2	3	1	
Methyl amyl ketone	1	2	0		Methyl isocyanate	4	3	2	W
Methyl anthranilite	0	1	0		Methyl isopropenyl ketone	2	-	0	
Methyl benzoate	0	2	0		Methyl Lactate	1	2	0	
Methyl borate	2	3	1		Methyl Mercaptan	4	4	0	
Methyl bromide	3	1	0		Methyl Methacrylate	2	3	2	
3-Methyl-1-butene	2	4	0		4-Methylmorpholine	2	3	0	
Methyl butyl ketone	2	3	0		1-Methylnapthalene	2	2	0	
2-Methyl butynol	2	3	0		Methyl nonyl ketone	0	2	0	
Methyl butyrate	2	3	0		Methyl n-propyl ether	0	3	0	
Methyl carbonate	3	3	0		Methyl para cresol	-	2	0	
Methyl cellosolve acetate	0	2	0		Methyl Parathion (solid)	4	1	2	
Methyl chloride	1	4	0		Methyl pentadecyle ketone	0	1	0	
Methyl chloroacetate	1	3	0		Methyl pentaldehyde	2	3	1	

Methyl cyclopentadiene	1	2	1		2-Methylpentane	1	3	0	
Methyl dihydroabietate	1	1	0		3-Methylpentane	1	3	0	
Methyl ether	1	4	1		2-Methyl-2,4-pentanediol	0	1	0	
2-Methyl-2-ethyl-1,3-dioxolane	2	3	0		2-Methylpentanoic acid	0	1	0	
Methyl ethyl ether	1	4	1		2-Methyl-1-pentanol	0	2	0	
Methyl ethyl ketone	1	3	0		2-Methyl-1-pentene	1	3	0	
Methyl formate	2	4	0		2-Methyl-2-pentene	1	3	0	
Methyl glycol acetate	1	2	0		3-Methyl-1-pentynol	1	2	0	
Methylamine	3	4	0		2-Methyl-1,3-pentadiene	0	3	0	
Methyl Amyl Ketone	1	2	0		2-Methyl-1,3-pentadiene	0	3	0	
Methyl Benzoate	0	2	0		4-Methyl-1,3-pentadiene	0	3	1	
2-Methylbiphenyl	2	-	0		4-Methyl-2-pentanol acetate	1	2	0	
2-Methylbutyraldeyde	2	3	0		2-Methyl-1-Pentene	1	3	0	
Methyl Borate	2	3	1		4-Methyl-2-Pentene	1	3	0	
Methyl Bromide	3	1	0		4-Methyl-1-Pentene	1	3	0	
3-Methyl-2-butanethiol	2	3	0		Methyl phenylacetate	0	2	0	
2-Methyl-1-butanol	2	2	0		Methylphenyl carbinol	0	2	0	
2-Methyl-2-butanol	1	3	0		Methyl phenyl carbinyl acetate	0	2	0	
2-Methyl-1-butene	2	4	0		Methyl phthaly ethyl glycolate	2	1	0	
2-Methyl-2-butene	2	3	0		2-Methyl-2-propanethiol	2	3	0	
Methyl Butyl Ketone	2	3	0		2-Methylpropenal	3	3	2	
Methyl Carbonate	3	3	0		2-Methylpropene	1	4	0	
Methyl Cellosolve Acetate	0	2	0		Methyl propionate	1	3	0	
Methyl Chloride	2	4	0		Methyl propyl acetylene	-	3	-	
Methyl Chloroacetate	2	2	1		Methyl Phenylacetate	0	2	0	
Methyl chloromethyl ether, anhydrous	3	3	2		1-Methyl Piperazine	2	2	0	

Methylcyclohexane	2	3	0		Methyl Propionate	1	3	0	
2-Methylcyclohexanol	-	2	0		Methyl propyl carbinol	0	2	0	
3-Methylcyclohexanol	0	2	0		Methyl Propyl Ketone	2	3	0	
4-Methylcyclohexanol	-	2	0		2-Methylpyrazine	2	2	0	
Methylcyclohexanone	-	2	0		Methyl pyrrole	2	3	1	
Methyl Vinyl Ketone	4	3	2		Methyl pyrrolidine	2	3	1	
Mineral Oil	0	1	0		1-Methyl-2-pyrrolidine	2	1	0	
Mineral seal oil typical	0	2	0		Methyl Salicylate	1	1	0	
Mineral Spirits	0	2	0		Methyl Stearate	0	1	0	
Mono-(trichloro)tetra-(mono-potassium dichloro)-penta-s-triazinetrione acid	3	0	2	W, OX	2-Methyltetrahydrofuran	2	3	0	
Monochloro-s-triazinetrione acid	3	0	2	W, OX	Methyl Toluene Sulfonate	2	1	0	
Morpholine	3	3	0		Methyl trichlorosilane	3	3	2	W
Mustard Oil	3	2			Methyl undecyl ketone	1	1	0	

GUIDE TO HAZARD INFORMATION – (N – O)

Compound	**H**	**F**	**R**	**S/N**	**Compound**	**H**	**F**	**R**	**S/N**
n,n-bis-(1,4-dimethylpentyl)p-phenylenediamine	**2**	**1**	**0**		Naphthylamine	**2**	**1**	**0**	
n,n-bis (1-methylheptyl) ethylenediamine	**0**	**1**	**0**		Natural gas, liquefied	**3**	**4**	**0**	
n,n-di-sec-butyl-p-phenylenediamine	**2**	**1**	**0**		Neatsfoot oil	**0**	**1**	**0**	
n,n-dibutyl acetamide	**0**	**1**	**0**		Neopentyl glycol	**1**	**1**	**0**	
n,n-dibutyl aniline	**3**	**1**	**0**		Nickel Carbonyl	**4**	**3**	**3**	
n,n-dibutyl stearamide	**0**	**1**	**0**		Nickel catalyst, dry	**2**	**4**	**1**	
n,n-dibutyltoluenesulfonamide	**0**	**1**	**0**		Nicotine	**4**	**1**	**0**	
n,n-diethylacetoacetamide	**0**	**1**	**0**		Nitric Acid	**3**	**0**	**0**	OX
n,n-diethylaniline	**3**	**2**	**0**		Nitric oxide	**3**	**0**	**0**	**OX**

n,n-diethyl-1,3-butanediamine	2	2	0		p-Nitroaniline	3	1	3	
n,n-diethylethanolamine	3	2	0		Nitrobenzene	3	2	1	
n,n-diethyl ethylenediamine	3	2	0		1,3-Nitrobenzotrifluoride	-	1	-	
n,n-diethyllauramide	-	2	0		Nitrobiphenyl	2	1	0	
n,n-diethylstearamide	0	1	0		Nitro chlorobenzene	3	1	1	
n,n-diisopropylethanolamine	1	2	0		Nitrocyclohexane	2	2	3	
n,n-dimethylaniline	3	2	0		Nitroethane	1	3	3	
n,n-dimethylformamide	1	2	0		Nitrogen (liquefied)	3	0	0	
n,n-dimethylisopropanolamine	2	3	0		Nitrogen dioxide, liquefied	3	0	0	OX
n-(2-cyanoethyl) cyclohexylamine	2	1	0		2-Nitropropane	1	3	2	
n-(2-ethylhexyl)-cyclohexylamine	2	1	0		o-Nitrotoluene	2	1	4	
n-(2-hydroxyethyl) cyclohexylamine	3	1	0		Nonadecane	0	1	0	
n-(2-hydroxyethyl) propylene diamine	2	1	0		Nonane	0	3	0	
n-(2-phenoxyethyl) aniline	1	1	0		Nonene	0	3	0	
n-(3-aminopropyl) cyclohexylamine	2	2	0		Nonyl acetate	1	2	0	
n-(3-aminopropyl) morpholine	2	1	0		Nonyl benzene	0	1	0	
n-2-(ethylhexyl) aniline	3	1	0		Nonyl naphthalene	0	2	0	
n-acetyl ethanolamine	1	1	1		Nonylphenol	2	1	0	
n-acetyl morpholine	2	1	1		2,5-Norbornadiene	-	3	1	
n-benzyldiethylamine	2	2	0		o-Acetoacetanisidide	2	1	0	
n-butyl acetamide	2	1	0		o-amyl phenol	2	1	0	
n-butyl ethanolamine	1	2	0		o-Anisidine	2	1	0	
n-butyl isocyanate	3	2	2		o-Bromo toluene	2	2	0	
n-butyl monoethanolamine	1	2	0		o-Chlorobenzotrifluoride	2	2	1	
n-butyl acetanilide	2	1	0		o-chloronitrobenzene	3	1	0	
n-butylaniline	3	1	0		o-chlorophenol	3	2	0	
n-butyl cyclohexylamine	2	1	0		o-cresol	3	2	0	

n-butyldiethanolamine	2	1	0		o-cyclohexyl phenol	2	1	0	
n-butyl urethane	-	2	0		o-dianisidine	-	1	0	
n-dibutyl tartrate	0	2	0		o-dichlorobenzene	2	2	0	
n-ethyl acetanilide	0	2	0		o-diethyl benzene	2	2	0	
n-ethyl acetamide	1	1	0		o-dihydroxy benzene	-	1	0	
n-ethyl cyclohexylamine	3	3	0		o-ethyl toluene	-	2	0	
n-ethyldiethanolamine	2	1	0		o-methoxy benzaldehyde	2	1	0	
n-ethyl ethanolamine	1	2	0		o-nitrotoluene	3	1	1	
n-methyl butylamine	3	3	0		o-phenetidine	2	1	0	
n-methyldiethanolamine	1	1	0		o-phenylenediamine	-	1	0	
n-methyl ethanolamine	2	2	0		o-phenyl phenol	1	1	0	
n-phenyl-n-ethyl ethanolamine	2	1	0		o-terphenyl	0	1	0	
n-phenyldiethanolamine	1	1	0		o-toluidine	3	2	0	
n-phenyl ethanolamine	1	1	0		o-tolyl-p-toluene sulfonate	1	1	0	
n-propyl bromide	2	3	0		o-xylene	2	3	0	
n-propyl butyrate	0	3	0		o-xylidine	3	1	0	
n-propyl ether	-	3	0		Octadecane	0	1	0	
Naphtha	1	3	0		Octadecylene alpha	0	1	0	
Naphtha 49 degree be-coal tar type	2	2	0		Octadecyl trichlorosilane	3	2	2	
Naphtha VM & P, 50 flash (10)	1	3	0		Octane	0	3	0	
Naphtha VM & P, high flash	1	3	0		1-Octanethiol	2	2	0	
Naphtha VM & P, regular	1	3	0		2-Octanol	1	2	0	
Naphthalene	2	2	0		1-Octene	1	3	0	
Nitrogen oxides	3	0	0	OX	2-Octene	1	3	0	
Nitrogen pentoxide	3	0	0	OX	Octyl alcohol	1	2	0	
Nitrogen Peroxide	3	0	0	OX	Octylamine	2	2	0	
Nitrogen, refrigerated liquid	3	0	0		Octyl chloride	1	2	0	

Nitrogen Trioxide	3	0	0	OX	Octylene glycol	1	1	0	
Nitroglycerine	2	2	4		Oleic Acid	0	1	0	
Nitromethane	1	3	4		Oleo oil	0	1	0	
1-Nitronapthalene	1	1	0		Olive Oil	0	1	0	
1-Nitropropane	1	3	2		Oxalic Acid	3	1	0	
2-Nitro-p-toluidine	2	1	4		Oxygen (liquid)	3	0	0	OX

GUIDE TO HAZARD INFORMATION – (P – R)

Compound	H	F	R	S/N	Compound	H	F	R	S/N
p-acetotoluidide	2	1	-		Phosphorus Pentasulfide	2	1	2	W
p-benzoquinone	1	2	1		Phosphorus, Red	1	1	1	
p-Bromo toluene	2	2	0		Phosphorus, White or Yellow	4	4	2	
p-chlorobenzaldehyde	2	2	0		Phosphorus Tribromide	3	0	2	W
p-cresyl acetate	1	2	0		Phosphorus Trichloride	4	0	2	W
p-chlorophenol	3	1	0		Phosphorus, White or Yellow	3	3	1	
p-cymene	2	2	0		Phosphoryl Chloride	3	0	2	W
p-dichlorobenzene	2	2	0		Phthalic Acid	0	1	1	
p-diethyl benzene	2	2	0		Phthalic Anhydride	3	1	0	
p-dihydroxy benzene	-	1	0		4-Picoline	2	2	0	
p-dioxane	2	3	1		Pinane	0	1	0	
p-ethyl phenol	2	1	0		Pine oil	0	2	0	
p-ethyl toluene	-	2	0		Pine pitch	0	1	0	
p-methyl acetophenone	0	1	0		Pine tar	0	2	0	
p-nitroaniline	3	1	2		Pine tar oil	0	2	0	
p-nitro chlorobenzene	2	1	3		Picric Acid	3	4	4	
p-nitrophenol	3	1	2		2-Picoline	2	2	0	

p-nitrotoluene	3	1	1		Pine Oil	0	2	0	
p-octyl phenyl salicylate	1	1	0		Pine Tar	0	2	0	
p-phenetidine	2	1	0		Piperazine	2	2	0	
p-sec-amyl phenol	1	1	0		Piperidine	3	3	0	
p-tert-amyl aniline	3	1	0		Polyamyl naphthalene mixture of polymers	0	1	0	
					Polychlorinated biphenyls	2	1	0	
2-(p-tert-amylphenoxy) ethanol	1	1	0		Polyethylene glycols	0	1	0	
2-(p-tert-amylphenoxy) ethyl laurate	0	1	0		Polyoxyethylene lauryl ether	0	1	0	
p-tert-amylphenyl butyl ether	0	1	0		Polypropylene glycols	0	1	0	
p-tert-amylphenyl methyl ether	0	1	0		Polyvinyl alcohol	0	2	0	
p-tert-butyl-o-cresol	2	1	0		Poppy seed oil	0	1	0	
p-toluene sulfonic acid	3	1	1		Potassium	3	1	2	W
p-toluidine	3	2	0		Potassium, metal	3	3	2	W
p-xylene	2	3	0		Potassium Bromate	1	0	0	OX
Palm kernel oil	0	1	0		Potassium Chlorate	2	0	0	OX
Palm oil	0	1	0		Potassium Cyanide	3	0	0	
Paraffin Oil	0	1	0		Potassium dichloro-s-triazinetrione	3	0	2	OX
Paraformaldehyde	3	1	0		Potassium Hydroxide (lye)	3	0	1	
Paraldehyde	2	3	1		Potassium Nitrate	1	0	0	OX
Parathion	4	1	2		Potassium Permanganate	1	0	0	OX
Peanut oil	0	1	0		Potassium Peroxide	3	0	1	W
Pent acetate	2	3	0		Potassium Persulfate	1	0	0	OX
Pentachlorophenol (dry)	3	0	0		Potassium Sulfide	2	1	0	
1,3-Pentadiene (cis and trans mix)	0	4	2		Potassium sulfide, anhydrous	3	1	0	
1,2,3,4,5-Pentamethyl benzene 95%	-	2	0		Potassium xanthanate	2	1	0	
Penta methylene oxide	2	3	1		Propionaldehyde (or propanal)	2	3	2	

Pentane	1	4	0		Propane	1	4	0	
1,5-Pentanediol	1	1	0		1,3-Propanediamine	2	3	0	
2,4-Pentanedione	2	2	0		Propargyl alcohol	4	3	3	
Pentanoic Acid	2	1	0		Propargyl bromide	3	3	4	
3-Pentanol	1	2	0		P-dioxane	2	3	1	
Pentaphene	2	1	0		Propenyl ethyl ether	2	3	0	
1-Pentene	1	4	0		Propionic anhydride	3	2	1	
1-Pentyne	-	3	3		Propionic nitrile	4	3	1	
Peracetic acid diluted with 60% of acetic acid	3	2	4	OX	Propionyl Chloride	3	3	1	
Perchloric Acid	3	0	3	OX	Propyl Acetate	1	3	0	
Perchloroethylene	2	0	0		Propyl Alcohol	1	3	0	
Perchloroethylene, tetrachloroethylene	2	0	0		2-Propybiphenyl	0	1	0	
Perhydrophenanthrene	-	-	0		Propylamine	3	3	0	
Perilla oil	0	1	0		Propyl benzene	2	3	0	
Petroleum, Crude	1	3	0		Propyl Chloride	2	3	0	
Petroleum Ether	1	4	0		Propyl chlorothiolformate	2	2	0	
Petroleum sulfonate	0	1	0		Propyl cyclohexane	0	-	0	
Phenanthrene	-	1	0		Propyl cyclopentane	0	-	0	
Phenethyl alcohol	1	1	0		Propylene	1	4	1	
Phenol	4	2	0		Propylene carbonate	1	1	0	
Phenoxy ethyl alcohol	0	1	0		Propylene diamine	2	3	0	
Phenylacetaldehyde	1	2	0		Propylene Dichloride	2	3	0	
Phenyl Acetate	1	2	0		Propylene Glycol	0	1	0	
Phenyl acetate (beta)	0	1	0		Propylene Glycol methyl ether	0	3	0	
Phenylacetic Acid	1	1	0		Propylene Glycol methyl ether acetate	0	2	0	
1-Phenyl-2-butene	-	2	0		Propylene Glycol monoacrylate	3	1	2	

Phenyl didecyl phosphite	0	1	0		Propylene Oxide	3	4	2	
Phenyl di-o-xenyl phosphate	0	1	0		n-Propyl Ether	-	3	0	
o-Phenylenediamine	-	1	0		Propyl formate	2	3	3	
Phenyl hydrazine	3	2	0		Propyl Nitrate	2	4	3	OX
Phenylmercuric acetate (dry)	3	1	0		Propyl propionate	1	3	0	
Phenylmercuric acetate (organic solution)	3	2	0		Propyl trichlorosilane	3	3	1	
Phenylmethyl ethanol amine	2	1	0		Propyne	2	4	2	
4-Phenylmorpholine	2	1	0		Pyridine	3	3	0	
Phenylpropyl Alcohol	0	1	0		Pyroxylin solution	1	3	0	
Phenyl propyl aldehyde	-	1	0		Pyrrole	2	2	0	
Phenyl toluene o	-	1	0		Pyrrolidine	2	3	1	
Phenyl trichloro silane	3	2	0		2-Pyrrolidone	2	1	0	
Phorone	2	2	0		Quenching oil	0	1	0	
Phosgene	4	0	1		Quinoline	2	1	0	
Phosphine	4	4	2		Rape seed oil	0	1	0	
Phosphoric Acid	3	0	0		Resorcinol	-	1	0	
Phosphorous oxychloride	4	0	2	W	Rhodinol	0	1	0	
Phosphorus Pentachloride	3	0	2	W	Rosin oil	0	1	0	

GUIDE TO HAZARD INFORMATION – (S)

Compound	**H**	**F**	R	**S/N**	**Compound**	**H**	**F**	**R**	**S/N**
Safrole	-	1	0		Sodium Hydride	3	3	2	W
Salicylaldehyde	0	2	0		Sodium Hydroxide (lye)	3	0	1	
Salicylic Acid	0	1	0		Sodium hydrosulfite	2	1	2	
Santalol	-	1	0		Sodium Nitrate	1	0	0	OX

Sec-amyl acetate	1	3	0		Sodium Perchlorate	2	0	2	OX
Sec-amyl alcohol	1	3	0		Sodium Peroxide	3	0	1	OX
Sec-amylamine	2	3	0		Sodium-Potassium Alloys	3	3	2	W
Sec-butyl acetate	1	3	0		Sodium Sulfide	3	1	1	
Sec-butyl alcohol	1	3	0		Soybean oil	0	1	0	
Sec-butylamine	3	3	-		Sperm oil no. 1 & no. 2	0	1	0	
Sec-butylbenzene	2	2	0		Stannic Chloride	3	0	1	
Sec-butyl chloride	2	3	0		Stearic Acid	1	1	0	
Sec-butyl cyclohexane	0	-	0		Stearyl Alcohol	0	-	0	
Sec-hexyl alcohol	0	2	0		Stibine	4	4	2	
Sesame oil	0	1	0		Stoddard Solvent	0	2	0	
Silane	1	4	3		Straw oil	0	1	0	
Silane, (4-aminobutyl)-diethoxy methyl	3	2	1		Styrene	2	3	2	
Silicon tetrachloride	3	0	2	W	Styrene oxide	2	2	0	
Silicon tetrafluoride	3	0	2	W	Succinonitrile	-	1	0	
Silver Nitrate	1	0	0	OX	Sulfur	2	1	0	
Sodium	3	3	2	W	Sulfolane	2	1	0	
Sodium Chlorate	1	0	2	OX	Sulfur	2	1	0	
Sodium Chlorite	1	0	1	OX	Sulfur Chloride	3	1	1	
Sodium Cyanide	3	0	0		Sulfur Dioxide	3	0	0	
Sodium dichloro-s-triazinetrione dihydrate	2	0	1	OX	Sulfuric Acid	3	0	2	W
Sodium dichloro-s-triazinetrione dihydrate, anhydrous	2	0	2	OX	Sulfuryl chloride	3	0	2	
Sodium Fluoride	3	0	0						

GUIDE TO HAZARD INFORMATION – (T)

Compound	H	F	R	S/N	Compound	H	F	R	S/N
Tallow	0	1	0		Tributyl Phosphate	2	1	0	
Tallow Oil	0	1	0		Tributyl phosphine	0	1	0	
Tannic Acid	0	1	0		Tributyl Phosphite	2	1	1	
Tartaric acid(d,l.)	0	1	0		1,2,4-Trichlorobenzene	2	1	0	
Terephthalic acid	0	1	0		1,1,1-Trichloroethane	2	1	0	
Terephthaloyl Chloride	3	1	0		1,1,2-Trichloroethane	2	1	0	
Terpineol	0	2	0		Trichloroethylene	2	1	0	
Terpinyl acetate	0	2	0		Trichloro ethyl silane	3	3	0	
Tert-amyl chloride	1	3	0		Trichloroisocyanuric acid, dry	2	0	2	OX
Tert-butyl alcohol	1	3	0		1,2,3-Trichloropropane	3	2	0	
Tert-butylamine	2	4	0		Trichlorosilane	3	4	2	W
Tert-butyl aminoethyl methacrylate	2	1	0		Tridecanol	0	1	0	
Tert-butylbenzene	2	2	0		Tridecyl acrylate	1	1	0	
Tert-butyl carbinol	2	3	0		Tridecyl alcohol	0	2	0	
4-Tert-butyl-catechol	2	1	0		Tridecyl phosphite	0	1	0	
Tert-butyl chloride	2	3	-		Triethanolamine	2	1	1	
4-Tert-butyl-2-chlorophenol	2	1	0		1,1,3-Triethoxyhexane	1	1	0	
Tert-butylcyclohexane	0	-	0		Triethylaluminium	3	4	3	W
Tert-Butyldecalin	1	1	0		Triethylamine	3	3	0	
Tert-butyldiethanolamine	2	1	0		1,2,4-Triethylbenzene	-	2	0	
Tert-butyl hydroperoxide	1	4	4	OX	Triethylborane	1	3	3	W
Tert-butyl-m-cresol	2	2	0		Triethyl citrate	0	1	0	
Tert-butyl peracetate	2	3	4		Triethylene glycol	0	1	0	
Tert-butyl perbenzoate	0	3	4	OX	Triethylene glycol diacetate	0	1	0	
Tert-butyl peroxypivalate	0	3	4	OX	Triethylene glycol, dimethyl ether	1	1	0	
4-Tert-butyl-2-phenylphenol	1	1	0		Triethyleneglycol monobutyl ether	0	1	0	

Tert-butyl styrene	2	2	2		Triethylenetetramine	3	1	0	
Tert-butyl tetralin	2	1	0		Triethyl Phosphate	0	1	1	
Tert-decyl mercaptan	2	2	0		Trifluoro chloroethylene	-	4	0	
Tert-dodecyl mercaptan	2	1	0		Triglycol dichloride	2	1	0	
Tert-hexadecane thiol	0	1	0		Trihexyl phosphite	-	1	0	
Tert-isohexyl alcohol	-	2	0		Triisobutyl aluminum	3	4	3	W
Tert-nonyl mercaptan	2	2	0		Triisobutyl Borate	3	2	1	
Tert-octylamine	-	3	0		Triisopropanol amine	2	1	0	
Tert-octyl-mercaptan	2	2	0		Trifluorochloroethylene	-	4	0	
Tert-tetradecyl mercaptan	2	1	0		Triisopropyl benzene	0	1	0	
Tetraamylbenzene	0	1	0		Trilauryl trithiophosphite	0	1	0	
1,1,2,2 Tetra bromoethane	3	0	1		Trimethoxysilane	4	3	2	
Tetra chlorobenzene	0	1	0		Trimethylaluminum	-	3	3	W
1,2,4,5-Tetracholorbenzene	1	1	0		Trimethylamine	3	4	0	
Tetrachloroethylene	2	0	0		1,2,3-Trimethylbenzene	0	2	0	
Tetradecane	0	1	0		1,2,3-Trimethylbenzene 90.5%	0	2	0	
Tetradecanol	0	1	0		1,2,4-Trimethylbenzene	0	2	0	
1-Tetradecene	0	1	0		2,2,3-Trimethylbutane	0	3	0	
Tetra ethoxy propane	0	2	0		2,3,3-Trimethyl-1-butene	0	3	0	
Tetraethylene Glycol	1	1	0		Trimethylchlorosilane	3	3	2	W
Tetraethylene pentaamine	2	1	0		1,3,5-Trimethylcyclohexane	0	-	0	
Tetraethyl Lead Compounds	3	2	3		Trimethyl cyclohexanol	2	2	0	
Tetrafluoroethylene	2	4	3		3,3,5-Trimethyl-1-cyclohexanol	2	2	0	
1,2,3,6-Tetrahydrobenzaldehyde	2	2	0		Trimethylene glycol	1	-	0	
Tetrahydrofuran	2	3	1		2,5,5-Trimethylheptane	0	2	0	
Tetrahydrofurfuryl alcohol	2	2	0		2,2,5-Trimethylhexane	2	3	0	
Tetrahydrofurfuryl oleate	1	1	0		3,5,5-Trimethylhexanol	2	2	0	

Tetrahydronapthalene	1	2	0		2,4,8-Trimethyl-6-nonanol	0	2	0	
Tetrahydropyran-2-methanol	1	2	0		2,6,8-Trimethyl-4-nonanol	2	2	0	
1,1,3,3-Tetramethoxypropane	0	2	0		2,6,8-Trimethyl-4-nonanone	2	2	0	
Tetramethoxysilane	3	3	1		Trimethylolpropane triacrylate	0	1	0	
1,2,3,4-Tetramethylbenzene 95%	0	2	0		2,2,3-Trimethylpentane	0	3	0	
1,2,3,5-Tetramethylbenzene 85.5%	0	2	0		2,2,4-Trimethylpentane	-	3	0	
1,2,4,5-Tetramethylbenzene 95%	0	2	0		2,3,3-Trimethylpentane	0	3	0	
Tetramethyleneglycol	0	1	0		2,2,4-Trimethyl-1,3-pentanediol	0	1	0	
Tetramethyl Lead, Compounds	3	3	3		2,2,4-Trimethylpentanediol diisobutyrate	0	1	0	
2,2,3,3-Tetramethyl pentane	0	3	0		2,2,4-Trimethyl-1,3-pentanediol isobutyrate	0	1	0	
2,2,3,4-Tetramethyl pentane	0	3	0		2,2,4-Trimethylpentanediol isobutyrate benzoate	0	1	0	
Tetramethyl tin	2	-	0		2,3,4-Trimethyl-1-pentene	0	3	0	
Tetraphenyl tin	3	1	0		2,4,4-Trimethyl-1-pentene	2	3	0	
Tetra (2-ethylbutyl) silicate	1	1	0		2,4,4-Trimethyl-2-pentene	2	3	0	
Tetra (2-ethylhexyl) silicate	1	1	0		3,4,4-Trimethyl-2-pentene	0	3	0	
Thialdine	2	2	1		Trimethyl phosphite	0	2	0	
2,2-Thiodethanol	1	1	0		Tri-n-butyl borate	3	2	1	
Thiodiglycol	2	1	0		Trinitrobenzene	2	4	4	
Thionyl Chloride	4	0	2	W	Trinitrotoluene (TNT)	2	4	4	
Thiophene	2	3	0		Tri-o-cresyl-phosphate	2	1	0	
1,4-Thioxane	2	2	0		Trioctyl phosphite	0	1	0	
Tin tetrachloride, anhydrous	3	0	1		Trioxane	2	2	0	
Titanium Tetrachloride	3	0	2		Triphenylmethane	0	1	0	
Tin tetrachloride, anhydrous	3	0	1		Triphenyl phosphate	2	1	0	

Toluene	2	3	0		Triphenyl phosphite	0	1	0	
Toluene-2,4-Diisocyanate	3	1	3	W	Triphenyl phosphorous	0	1	0	
Toluhydroquinone	-	1	0		Tripropyl aluminum	-	3	3	W
o-Toluidine	3	2	0		Tripropylamine	2	2	0	
Transformer oil	0	1	0		Tripropylene	0	3	0	
Triamylamine	2	1	0		Tripropylene Glycol	0	1	0	
Triamylbenzene	0	1	0		Tripropylene Glycol methyl ether	0	1	0	
Triamylborate	1	2	0		Tung Oil	0	1	0	
Tributylamine	3	2	0		Turkey red oil	0	1	0	
Tributyl citrate	0	1	0		Turpentine	1	3	0	
					Triethylenetetramine	3	1	0	

FORMS

CHEMICAL INVENTORY

Building		**Room(s) #**	
Contact Name		**Department**	
Phone		**E-mail**	

Chemical Name	***CAS #***	***Average Stored***		***Maximum Stored on Hand***		***Storage Method[2]***	***Physical Form[3]***
		Quantity	**Units[1]**	**Quantity**	**Units[1]**		

[1] Milli-gram (mg), milli-liter (ml), pound (lb)…etc.

[2] Metal can< 5 gal (MCl); Metal can> 5gal (MC2); Plastic container< 5 gal (PC!); Plastic container> 5 gal (PC2); Fiber/tic box (FB); Glass Bottle (GB); Cylinder I; Bag (B); Carboys (CR).

[3] Solid (S); Liquid (L); Gas (G).

REQUEST FOR DISPOSAL- HAZARDOUS CHEMICALS

Requested by:	**Department:**	**Phone:**

Container Tag #	**Contents** **Use full chemical or product name(s) – List all components**	**% of Container**	**Total amount of contents**	**Physical State** **(S or L)**
		100%		
		100%		

		100%		

The materials listed are accurately described above and are packaged and labeled according to the procedures of the College of Engineering Safety Manual.

Signature---------- Date: ----------

(Must be College of Engineering Employee, e.g. faculty, staff, TA or RA)

HAZARD REVIEW PREPARATION CHECKLIST

Consult the Material Safety Data Sheet (MSDSs) for Hazard

Chemicals	Flammable	Reactive	Toxic	Corrosive	Radioactive
Liquids					
Solids					
Gases					

Can these hazards exist?

• Explosion	• Falls	• Implosion
• Struck By	• Electrocution	• Caught Between
• Electric Shock	• Sharps / cuts	• Electric Burn

• Air contamination	• Thermal Burn (hot)	• Water contamination
• Thermal Burn (cold)	• Soil contamination	• RF exposure
• Muscle Strain	• RF burn	• Eye strain
• Allergic Reaction	• Exothermic Reaction	• Oxygen Displacement
• Chemical Asphyxiation	• Excessive Noise	• Intense Light
• Laser	• Pinch Points	

LABORATORY CLEARANCE: CHECKLIST

Name of Researcher	**Laboratories/Work Areas**
Chemicals Search out and evaluate all chemicals and label all containers. Transfer responsibility for material to Signed ..... Prepare chemical waste for disposal. Clean glassware, refrigerators, ovens *etc*. Clean working area. Sign out **Radioactive Material** Label and secure material. Check for Stock Cards. Dispose of waste. Update Stock Cards. Transfer responsibility for material to: Signed..... Update Stock Cards. Sign out	**Micro-organisms and Cultures** Label and secure material. Autoclave waste. Clean glassware, incubators, ovens, and refrigerators. Transfer responsibility for material to Signed..... Decontaminate and clean the working area. Sign out **Mixed Hazard Material** Complete the appropriate clearing and decontamination procedures outlined above. **Equipment** Unwanted equipment decontaminated and cleared to waste. Equipment to be left transferred to: Signed..... Custom equipment instructions and risk assessment. Gas Cylinders to Store. Clean the working area. Sign out.

Signature Researcher ….....….Date….....

Signature lab Engineer….....……Date….....

GENERAL PROJECT RISK ASSESSSMENT

College of Engineering, UAE University

General Project Risk Assessment	Project Reference:

This form should be completed by the Research Supervisor initiating the project. The assessment is normally valid for the length of the project but must be reviewed EACH SEMESTER and supplemented whenever there is a significant change in the nature of the work to be performed.

Name of the Research Supervisor	Name of the Research Worker*	Lab. No.

***Status: Undergraduate, R.A., Postgraduate or Visitor (highlight as appropriate).**

Project Title:

Give a brief description of the work to be undertaken including the nature of materials and techniques to be used.

Special Hazards:

Indicate any ***special*** hazards associated with the work e.g. from use of biological material especially any of human origin, (whose ***use must be justified***), from use of material of high toxicity or hazardous instability or from any other physical or chemical source.

- If any such hazards are expected, indicate which safety resources within the College of Engineering are to be used to deal with these hazards.
- If no such safety resources exist within the College of Engineering indicate how the expected hazards are to be dealt with.
- If no special hazards are anticipated write “none” in the box below.

Date.....**Review Due Date**.....

Electronic form should be sent to the Department' Chair.

REPORT OF AN INJURY OR DANGEROUS OCCURRENCE

File #

Complete this Form and Forward it to the Department Chair within 3 Days of the Incident

Serious Accidents Should Be Reported by Phone Immediately On **9-998**

Use BLOCK CAPITALS

Part A: About the incident

1. On what date did the incident happen?

2. At what time did the incident happen?

3. Where did the incident happen?

Department:

Building:

Part B: About the injured person

1. Full name

2. Home address and telephone number

3. Age

4. Sex

Part of Building

4. Name of person reporting incident.

5. Were there any witnesses? If so please give their name(s) and department(s).

6.9.5 Was anyone injured? If

5. University Employee Yes No

6. Job title/student Category

7. Department

Part D: About the injury

1. What was the injury? (e.g. fracture, laceration, burn etc.)

2. What part of the body was injured?

3. What first aid treatment (if any) was given?

yes go to Part B. If no go to Part E.

Yes

No

4. Who administered first aid?

Part E: Describing what happened

6.9.6 Give as much detail as you can. For example:

- the name of any substance involved
- the name and type of any machine
- the events that led to the accident/incident
- the part played by any people
- what you were doing at the time of the accident/incident

I agree to a medical report of my injuries in respect of the accident referred to on this form being supplied to the College of Engineering*

Sign and print name:

Signature of injured person/reporter

of dangerous occurrence

Date:

*Delete if not appropriate

MEDICAL EVALUATION AND WORKPLACE EXPOSURE QUESTIONNAIRE

To the employer:

Answers to questions in Section 1, and to question 9 in Section 2 of Part A, do not require a medical examination.

To the employee: Can you read: Yes No

(If you have completed this form within 3 months you do not need to complete this form).

To maintain confidentiality, your employer must not look at or review your answers, and your employer must tell you how to deliver or send this questionnaire to the health care professional who will review it.

Section 1. (Mandatory)

The following information must be provided by every employee who has been selected to use any type of respirator.

1. Today's date:

2. Your name

3. Date of birth:

4. Sex: M F

5. Your height: cm

6. Your weight: kg

6.9.8 **A phone number where you can be reached by the health care professional who review this questionnaire**

9. The best time to call you at this number: AM PM.

6.9.9 Has your employer told you how to contact the health care profe[Yes] to [No] this questionnaire?

6.9.10 **Check the type of the respirator you will use** (you may check more than one category)

[ ] N, R, or P disposal respirator (filter mask, non-cartridge type only)

[ ] Other type (half or full-face piece type, powered-air purifying, supplied-air, self-contained breathing).

6.9.11 **Have you worn a respirator?** [Yes] [No]

a. if yes, what type(s): [ ]

b. Extent of respirator usage [ ]daily [ ]weekly [ ] less than once/week [ ]rarely [ ]in emergency

c. Estimate length of time respirator will be worn in one day: [ ] hr

d. Date of most recent fit test [ ]

6.9.12 **Describe the job activities you are involved in:**

6.9.13 **List as completely as possible the materials, chemicals or substances with which you work:**

6.9.14 **Do you wear or use any of the following protective equipment?**

	Yes	No
Hearing protection		
Lab coat or protective clothing		
Gloves		
Safety glasses or goggles		
Safety shoes		
Shoe covers or hair covers		
Exhaust hood or containment devices		
Hard hat		
Welding goggles		
Other		

16. Do you work with or have significant exposure to any of the followings?

	Yes	No

Vapors or gases		
Dust		
Fumes or mists: [ ] paint, [ ] Welding, [ ] other specify…….		
Pesticides		
Solvents		
Metals		
Lead		
Biological agents		
Infectious agents		
Laboratory animals		
Loud noise		
Extreme heat or cold		
Vibration		
Radiation		
Emergencies		
Hazardous waste		
Unusually demanding hand or arm duties		

17. Have you ever

	Yes	No
Filed a compensation claim or received benefits for an occupational accident, injury or illness?		
Been disabled or restricted for medical reasons?		
Changed jobs for health or safety reasons?		
Had difficulty wearing a respirator?		
Do you have hobbies (such as painting, gardening, welding, woodworking, hairdressing, or scuba diving) which involve exposure to chemicals or physical hazard		
Are there any substances in or around your home that might be harmful? (fumes, gases, pesticides, paints or others)		

Do you have more than one job? Explain if yes		
On the average how many hours per week do you work? **……**		

18. Does your job involve the following work considerations?

	Yes	No
Special need for visual or hearing		
High pressure		
Confined space entry		
High or low temperature		
Additional protective equipment/clothing (estimate weight in kg):		
Exposure to highly toxic materials (not listed in item 14)		
Other working considerations? List		

Have you been selected to use any type of respirator? Yes No

If your answer to the above question is **yes**, then you must answer all questions in Section 2 below.

Section 2. (Mandatory)

6.9.15 **Do you currently smoke, or have smoked in the last month?**

	Yes	No

6.9.16 **Have you ever had any of the following conditions?**

	Yes	No
Seizures?		
Diabetes?		
Allergic reactions that interfere with your breathing?		
Claustrophobia (fear of closed-in places)?		
Trouble smelling odors?		

6.9.17 **Have you ever had any of the following pulmonary or lung problems?**

	Yes	No
Asbestosis		
Asthma		
Chronic bronchitis		
Emphysema		
Pneumonia		
Tuberculosis		
Silicosis		

Pneumothorax (collapsed lungs)		
Lung cancer		
Broken ribs		
Any chest injury or surgery		
Any other lung problem that you have been told about		

6.9.18 **Do you currently have any of the following symptoms of pulmonary or lung illness?**

	Yes	No
Shortness of breath		
Shortness of breath when walking fast on level ground or walking up slight hill		
Shortness of breath when walking with other people at an ordinary pace on level ground		
Have to stop for breath when walking at your own pace on level ground		
Shortness of breath when washing or dressing yourself.		
Shortness of breath that interferes with your job		
Coughing that produces phlegm (thick sputum).		
Coughing that wakes you early in the morning		
Coughing that occurs mostly when you are lying down		
Coughing up blood in the last month.		
Wheezing		
Wheezing that interferes with your job		
Chest pain when breathe deeply		
Any other symptoms that you think may be related to lung problems		

6.9.19 **Have you ever had any of the following cardiovascular or heart problems?**

	Yes	No
Heart attach		
Stroke		
Angina		
Heart failure		
Swelling in your legs or feet (not caused by walking)		
Heart arrhythmia (heart beating irregularly)		
High blood pressure		
Any other heart problem that you have been told about		

6.9.20 **Have you ever had any of the following cardiovascular or heart symptoms?**

	Yes	No
Frequent pain or tightness in your chest		
Pain or tightness in your chest during physical activity		
Pain or tightness in your chest that interferes with your job.		
In the past two years, have you noticed your heart skipping or missing a beat		
Heartburn or indigestion that is not related to eating		
Any other symptoms that you may think be related to heart or circulation problems		

6.9.21 **Do you currently take medication for any of the following problems?**

	Yes	No
Breathing or lung problems		
Heart trouble		
Blood pressure		
Seizures		

6.9.22 **If you have used a respirator, have you ever had any of the following problems?** (If you have never used a respirator, check the following space and go to question 9)

☐ Never used a respirator

	Yes	No
Eye irritation		
Skin allergies or rashes		
Anxiety		
General weakness or fatigue		
Any other problem that interferes with your use of a respirator		

6.9.23 **Have you ever lost vision in either eye (temporarily or permanently)? Explain if yes**

	Yes	No

6.9.24 **Do you currently have any of the following vision conditions?**

	Yes	No
Wear contact lenses		
Wear glasses		
Color blind		
Any other eye or vision problem. Explain if yes		

6.9.25 **Have you ever had an injury to your ears, including a broken ear drum? Explain if yes**

	Yes	No

6.9.26 **Do you currently have any of the following hearing conditions?**

	Yes	No
Difficulty hearing		
Wear a hearing aid		
Any other hearing or ear problem		

I understand the questions above and have answered truthfully and fully to the best of my knowledge. I hereby permit the College of Engineering designated health care provider to review this confidential information and to provide to my employer a statement to my capability to wear a protective respirator, without any disclosure of clinical diagnosis.

_____ _____

Employee's signature Date

For medical provider use only

Medical evaluation for respirator approval

Physician's comments

_____

_____

☐ Examination required ☐ Phone contact required ☐ Limited use/restriction

Physician's Name Signature Date

Student/Research Assistant Statement

This part should be filled by the Student or the Research Assistant

Name:	Student ID:
Department:	Laboratory Location:

This section should be filled by the instructor/PI

6.9.27 The above student/RA is requested to read the following part(s) of the safety manual (please indicate applicable parts)

☐ Part 2 Emergency situation	☐ Part 3 Emergency procedure
☐ Part 4 Safety rules	☐ Part 5 Chemical hazard
☐ Part 6 Biological Hazard	☐ Part 7 Mechanical Safety
☐ Part 8 Electrical Safety	☐ Part 9 Fire Safety
☐ Part 10 Hazardous Waste Disposal	☐ Part 11 Safety Training

B. The above student/RA is

☐ Student of a regularly offered course	☐ Student of a not regularly offered course (independent study, grad project)
☐ Research assistant	☐ Master student working on thesis

C.

Instructor/PI name:	Signature:	Date:

This part should be filled by the student or research assistant

I have read and understood the requested material in the Safety Manual. I am aware of the dangers in the Lab and know the precautions to be taken to avoid injury to others and myself in the Lab.	
Student/RA signature:	Date:

SAFETY SURVEY LIST

A. Working Areas

Department:	**Lab Manager:** **Email:**	**Date:**
Building:	**Room #:**	**Phone #:**

Item	Yes	No	NA	Comments
Adequate lighting in the work area?				
Laboratory work areas reasonably clean and tidy?				
Area kept as clean as work allows?				
Guards on fan blades are located within 2 m of the floor?				
Ladders and step-stools in good condition and used in the manner for which they were designed?				
Two and four-wheeled carts and hand trucks in good condition?				
List of emergency numbers, First Aid, and CPR certified employees clearly displayed?				
No foods, beverages, tobacco, or cosmetics in laboratory?				
Eating, drinking, use of tobacco, and use of cosmetics prohibited in the laboratory?				
No chipped or broken glassware in use?				

SAFETY SURVEY LIST

B. Means of Egress

Department:	Laboratory Manager: Email:	Date:
Building:	Room #:	Phone #:

Item	Yes	No	NA	Comments
Stairs well lit?				
Stairs of sturdy design?				
Railings provided on all open sides of exposed stairways?				
Anti-skid walking surfaces on the stairs?				
Stairs clean?				
All non-exit doors and passages which could be mistaken for an exit marked as such?				
All exits clearly designated?				
All exits unobstructed?				
All exit signs illuminated? (They must be illuminated by general room lighting or internal lighting.)				
Emergency lighting provided for fire escape routes?				
Emergency lighting provided for fire escape routes?				
All fire doors unobstructed and free of locks and devices that could prevent free egress?				
Designated fire doors closed and operable?				
All fire doors side hinged and swing in the direction of the escape?				
Floors free from large holes?				
Floors free from litter and obstructions?				
Floors clean and dry?				
Drainage provided for continuously wet floors?				

Mats and carpeting in good condition?				
Aisles and passageways well lit?				
Aisles and passageways kept clear to provide safe movement of materials handling equipment or employees?				
No loose or protruding shelving or edging that could cause a safety problem?				
Covers or guard rails provided for open pits, vats, etc.? Guard rails provided for platforms > 1 m above the adjacent floor?				

SAFETY SURVEY LIST

C. Materials Handling and Storage

Department:	**Laboratory Manager:** **Email:**	**Date:**
Building:	**Room #:**	**Phone #:**

Item	Yes	No	NA	Comments
Area free of the accumulation of materials that could cause tripping, fires, or explosions?				
Labeling appears on doors and cabinets?				
Storage shelving secure, in good condition, and not overloaded or crowded?				
Storage shelving provided with a flip on forward edge?				
Hazardous chemicals not stored on floor?				
Sufficient waste containers provided?				
Reagents used at the bench properly labeled to prevent accidental use of the wrong reagent or wash bottle?				
Containers labeled with the identity of contents and general hazard(s) of contents?				
Containers properly capped or sealed?				
Flammable liquids in quantities greater than one liter stored in safety cans designed for flammable liquid storage?				
Flammable and combustible liquids stored in containers labeled as such?				
Flammable and combustible liquids stored in approved cabinets marked “Flammable”?				
Cabinets properly ventilated?				
If flammable liquids are used in large volumes, is the mechanical ventilation adequate to remove vapors before they reach hazardous concentrations?				
Stored combustibles and flammables separated from any heat source by at least 6 m?				
Areas where flammables are used or stored designated “NO SMOKING – NO OPEN FLAMES”?				

Metal drums used for storage and dispensing of flammable liquids properly grounded?				
Materials stored only with other compatible materials? (e.g., solvents, acids, bases, reactive, oxidizers, and toxins stored separately)				
Flammables in the laboratory are less than 1000 Liters				
Absence of leaking containers in storage areas				
Absence of corroded containers in storage areas				

D. Compressed Gases

Department:	**Laboratory Manager:** **Email:**	**Date:**
Building:	**Room #:**	**Phone #:**

Item	Yes	No	NA	Comments
Each compressed gas cylinder marked with the identity of its contents?				
Compressed gas cylinders inspected visually for safe operating condition?				
Gas cylinders secured so they will not tip over or fall?				
Valve caps tightly in place on all gas cylinders that are not in use?				
All gas lines leading from compressed gas supplies labeled as to identity of gas, laboratory served, and emergency telephone numbers?				
Fewer than 3 cylinders in use in the laboratory?				
Fewer than 9 cylinders in the laboratory?				
Gas cylinder storage areas properly ventilated?				
Areas where flammable compressed gases are stored posted “NO SMOKING – NO OPEN FLAMES”?				
Oxygen cylinders not stored in the same vicinity of greasy or oily rags?				
Oxygen cylinders stored a minimum of 15 m from flammable gas cylinders or a minimum 2 m high fire wall with a 0.5-hour fire rating separates them?				

E. Electrical

Department:	Laboratory Manager: Email:	Date:
Building:	Room #:	Phone #:

Item	Yes	No	NA	Comments
All electrical equipment properly grounded? (Double insulated tools are exempt.)				
All electrical equipment U.L. listed and/or F.M. approved?				
Breaker boxes that may need maintenance while live have a minimum of 30" width clearance in front of them?				
All circuit breakers and fused circuits labeled to indicate whether they are in the open (off) or closed (on) position?				
Properly rated fuses used?				
All electrically live parts guarded?				
Electrical boxes and panels covered with face-plates to prevent exposure to live wires?				
Tool, appliance, instrument, and extension cords in good repair?				
Has permanent wiring been installed to alleviate the use of extension cords?				
Electrical cords or other lines not suspended unsupported across rooms or passageways?				
Cords not routed over metal objects?				
Cords not run through holes in walls or ceilings or through doorways or windows?				
Cords not placed under carpet, rugs, or heavy objects?				
Cords not placed in pathways or other areas where repeated abuse can cause deterioration of insulation?				
Octopus (multi-outlet) plugs not used? Approved multiple outlets with circuit breakers used instead?				

F. General Safety Equipment

Department:	Laboratory Manager: Email:	Date:
Building:	Room #:	Phone #:

Item	Yes	No	NA	Comments
Fire extinguishers located where flammable or combustible liquids are used?				
A fire extinguisher located between 3 m and 8 m of a door opening to rooms used for storage?				
Other extinguishers ready and accessible?				
Extinguishers mounted so that the top is not more than 1.5 m above the floor, and not more than 1 m if it weighs more than 20 kg?				
Extinguishers suitable for the class of fire anticipated in each area?				
Extinguishers inspected and labeled as inspected on a yearly basis?				
Employees instructed in the proper use of fire extinguishers on an annual basis?				
Fire alarm boxes readily accessible and within normal path distance of 60 m?				
Fire alarm system tested on an annual basis?				
Eyewash and safety showers installed within 8 m of laboratory work areas where corrosive chemicals are used?				
Safety showers and eyewash fountains easily accessible?				
Employees familiar with operation of safety showers and eyewash fountains?				
Safety showers and eyewash fountains tested at least annually?				
First aid kits available, in good condition, and plainly marked?				
Explosion-proof refrigerators not used for storage of food?				
Fume hoods in proper operating condition?				
Function of fume hoods periodically checked and results recorded and posted?				

Equipment properly placed in fume hoods? (i.e., instruments elevated a minimum of 5 cm from hood floor.)				
Fume hoods not used for storage?				

G. Personal Protection

Department:	**Laboratory Manager:** **Email:**	**Date:**
Building:	**Room #:**	**Phone #:**

Item	Yes	No	NA	Comments
Eye protection provided and used by all personnel when in the laboratory area?				
Eye protection provided for all guests that enter the laboratory?				
Proper laboratory clothing provided and used by all personnel when in the laboratory area?				
Laboratory clothing clean and in good repair?				
Gloves provided and used when needed?				
Proper gloves provided for each different operations?				
Employees who are required to wear steel toe shoes comply?				

H. Biosafety General Requirements

Department:	Laboratory Manager: Email:	Date:
Building:	Room #:	Phone #:

Item	Yes	No	NA	Comments
Is a copy of the laboratory safety manual available in the laboratory?				
Are all lab personnel trained in appropriate safety precautions and procedures?				
Is this training documented?				
Have emergency response plans for the handling of spills of infectious materials and for self-contamination/ personal injury involving infectious materials been developed?				
Are the emergency response plans ready for use?				
Are the personnel required to know, understand, and to follow standard practices and procedures?				
Is the lab kept neat, orderly and clean?				
Is protective lab clothing available, and worn properly fastened by all personnel, including visitors, trainees, and others entering or working in the laboratory?				
Is other Personal Protective Equipment available, worn when necessary, and is the personnel trained in the proper use of PPE?				
Is a written policy and procedure available that prohibits eating, drinking, the storing of food, beverages or utensils, applying cosmetics, and the inserting or removal of contact lenses in the laboratory?				
Is a written policy and procedure available that prohibits the recapping of needles and mouth pipetting in the laboratory?				
Is a written policy available that mandates the restraining or tying back of long hair?				
Is a written policy and procedure available that makes it mandatory to wash hands before leaving the laboratory, and at any time after handling materials known or suspected to be contaminated, even when gloves have been worn?				

Is a written policy and procedure available that mandates work surfaces to be cleaned and decontaminated with a suitable disinfectant at the end of the day and after any spill of potentially dangerous material?				
Is a written policy and procedure available that specifies that all procedures performed in a manner that minimizes the creation of aerosols?				
Is a written policy and procedure available that specifies that all spills, accidents, and overt or potential exposures are reported in writing?				
Are lab workers protected against relevant infection by immunization, where possible, and show immunity?				
Are lab workers protected against relevant infection by immunization, where possible, and show immunity?				
Are the personnel trained and competent in the disposal of bio-hazardous and biomedical wastes?				

I. Containment Level 2 Survey *

Department:	**Laboratory Manager:** **Email:**	**Date:**
Building:	**Room #:**	**Phone #:**

Item	Yes	No	NA	Comments
Are the lab doors self-closing and do doors remain closed except when individuals enter or exit the laboratory?				
Is hand washing facilities, soap and towels provided, preferably near the main point of exit?				
Are laboratory furnishings impervious and readily cleanable?				
Are separate hanging areas provided for street and lab clothes preferably near the exit?				
Is an autoclave available in or near the lab? If not, are bio-hazardous wastes transported to the autoclave in a manner that minimizes the potential for a spill?				
Are Class I or II biological safety cabinets used for all manipulations involving the bio-hazardous agent(s) which may create an aerosol?				
Has the biological safety cabinet been tested within the last 12 months?				
Is centrifugation carried out using closed containers or safety heads or sealed cups, and are those opened only in a biological safety cabinet?				
Are infected animals or insects housed in the lab or an appropriate animal containment facility?				
Is a written policy and procedure available that limits access to the laboratory to authorized individuals that have been advised of the potential hazards, and meet any specific entry requirements (immunization, not immune-compromised, etc.)?				
Are vacuum lines that are used for work involving bio-hazardous agent protected from contamination by filters or equivalent equipment?				
Is a written policy and procedure available that prohibits the wearing of lab coats and other PPE outside the containment laboratory?				

Is a written policy and procedure available that makes the wearing of gloves mandatory when the skin may be exposed to infectious materials or when infected animals are handled?				
Is a written policy and procedure available that mandates that potentially contaminated equipment is decontaminated before leaving the lab with procedures demonstrated to be effective?				
Are such authorized persons providing the same kind of protection from hazards as persons working in the laboratory?				

* Form H "Biosafety General Requirements" must be completed along with this form.

J. Containment Level 3 Survey*

Department:	**Laboratory Manager:** **Email:**	**Date:**
Building:	**Room #:**	**Phone #:**

Item	**Yes**	**No**	**NA**	**Comments**
Is the laboratory at negative pressure at all times and is there a control system to ensure that the lab is never positively pressurized relative to surrounding areas?				
Is the lab air exhausted through a filter system, or through a sealed, dedicated exhaust system discharging the air directly to the outside?				
Is the filtration system designed to allow in situ decontamination and testing?				

* Form H "Biosafety General Requirements" must be completed along with this form.

K. Lab Reopening Safety Inspection Checklist

PI:		Department:	
Building:		Room No:	
College:		Inspection Date:	

	Signage and Labeling	YES	NO	N/A	Remarks
1.1	Are the emergency procedures posted? (Emergency phone numbers, steps to take in case of emergency, etc.)				
1.2	Are biohazard warnings on freezers, refrigerators and storage units if needed?				
1.3	Material Safety Data Sheets Readily accessible				
1.4	Are secondary chemical containers labeled with their contents a hazards?				
2	**Housekeeping/Safety/Egress**	**YES**	**NO**	**N/A**	**Remarks**
2.1	Are evacuation routes for fire and safe shelters for weather emergencies clearly posted?				
2.2	Alarm systems are operating properly.				
2.3	Is lab free of trip hazards (wires, other obstructions, debris, etc.				
3	**Chemical Storage and Management**	**YES**	**NO**	**N/A**	**Remarks**
3.1	Do all primary chemical containers have clean, clearly labeled with chemical name(s)?				
3.2	Are chemicals segregated by hazard class? (liquids especially)				
3.3	Are acids, bases, flammables, and corrosives separated?				
3.4	Are acids segregated from one another by type (organic acids separated from inorganic acids, oxidizing acids, etc.?)				

3.5	No volatile chemical storage in unventilated environmental chambers				
3.6	Is there secondary containment under hazardous liquids?				
4	**Fire Safety**	**YES**	**NO**	**N/A**	**Remarks**
4.1	Are all flammables kept in Flammable Safety Cabinet when not in use?				
4.2	Paths free from obstruction				
4.3	Fire doors not blocked or wedged open				
4.4	Fire extinguishers unobstructed				
4.5	Are flammables stored only flammable safe or explosion proof refrigerators?				
5	**Gas Cylinders**	**YES**	**NO**	**N/A**	**Remarks**
5.1	Are gas cylinders secured with a chain or strap above the middl of the cylinder?				
5.2	Do gas cylinders without regulators have safety caps in place? Exempt- lecture bottle.				
5.3	Are toxic, pyrophoric or corrosive gases in gas cabinets?				
5.4	Do flammable gases have flow restrictors – AND is lab either sprinkler equipped or monitored for flammable gas leaks?				
5.5	Are reserve cylinders limited to one per operation/process?				
6	**Ignition sources**	**YES**	**NO**	**N/A**	**Remarks**
6.1	Are flammable liquid dispensing stations bonded and grounded				
6.2	Flammables separated from strong oxidizers and Flammable liquids not stored near hot plates or other ignition sources				
6.3	Are vacuum pumps and other ignition sources segregated from flammables/combustibles?				
7	**Electrical Hazards**	**YES**	**NO**	**N/A**	**Remarks**

7.1	Are electrical panels unobstructed (3 feet?) and Guards/covers used for electrophoresis devices				
7.2	Are extension cords on temporary equipment adequate and Flexible cords in good condition				
7.3	Are electrical cords in good condition (not frayed or damaged?)				
7.4	Is all equipment grounded via 3-prong plugs or polarized 2 prong plugs? (where possible to check)				
8	**Emergency Equipment / Hygiene**	**YES**	**NO**	**N/A**	**Remarks**
8.1	Eyewash and safety showers available in close proximity and unobstructed				
8.2	Are fire extinguishers appropriate?				
8.3	Do fire extinguishers have a current inspection tag?				
8.4	Are fire extinguishers visible and accessible?				
8.5	Are spill kits available, accessible and appropriate? (Biological, when appropriate)				
8.6	All exit doors clear and unobstructed? (2 per lab whenever possible)				
9	**Personal Protective equipment / Appropriate attire**	**YES**	**NO**	**N/A**	**Remarks**
9.1	Is everyone wearing appropriate clothing (i.e. long pants and closed toed shoes, no shorts or sandals?) Eye and face protection available where needed				
9.2	Are safety glasses or goggles worn in all wet bench labs and/or labs with high-pressure equipment?				
9.3	Are gloves appropriate and being used? Latex is not appropriate with solvents.				
9.4	Are lab coats/aprons available as appropriate and being used?				
10	**Physical Hazards**	**YES**	**NO**	**N/A**	**Remarks**
10.1	Do belts, pulleys or other moving parts on equipment have shields or guards attached to prevent entanglement?				
11	**Ventilation**	**YES**	**NO**	**N/A**	**Remarks**

11.1	Have fume hoods been checked				
11.2	Are the baffles and airfoil clear of equipment that could impede airflow?				
11.3	Is the sash closed/lowered when not in use?				
12	**Chemical Waste**	**YES**	**NO**	**N/A**	**Remarks**
12.1	Is chemical waste properly labeled? (Labeled with description of contents and dated with fill start date)				
12.2	Is waste in compatible containers? (e.g., no acids in metal containers)				
12.3	Are waste containers kept closed except when waste is being added?				
12.4	Are waste containers kept in secondary containment?				
13	**Sharps – Biohazard**	**YES**	**NO**	**N/A**	**Remarks**
13.1	Are sharps containers available as appropriate?				
13.2	Are needles and razor blades capped or covered?				
14	**COVID-19 Precaution and Control Measures**	**YES**	**NO**	**N/A**	**Remarks**
14.1	Is there an increase in the frequency of cleaning & disinfection processes at workplaces, tools & equipment on a daily basis after every use according to the requirements of Abu Dhabi Health Department?				
14.2	Is physical distance (at least two meters) is maintained by the faculty/staff and have suspend all activities which required gathering?				
14.3	Is there daily temperature checkup for staff to ensure no COVID 19 suspicious cases detected in the workplace?				
14.4	Is frequent hand washing practiced at workplace?				
14.5	Are sufficient hand sanitizers are fixed at laboratory and faculty /staff are ensuring the frequent usage?				
14.6	Is work from home ensured for sick or elderly people (60) or pregnant women?				

14.7	Does laboratory ensure 40% occupancy at work place?				
14.8	Does all staff/faculty are ensured wearing mandatory face mask while at work and Single use /disposable masks are considered?				
14.9	Is sickness reported to concerned laboratory in charge?				
14.10	Whether sterilization process has done in the laboratory?				
14.11	Whether used PPE are disposed in designated bins?				

Inspection conducted by: Signature:

Date:

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REFERENCES

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