SAFETY MANUAL

Safety and Emergency Protocols

Version 1.01

This document lists the safety protocols that need to be followed by all laboratories in IISc. It also mentions the procedures to be followed in emergency situations.
It was last updated in Mar 2019

Office of Laboratory Safety and Environmental Health
safety @iisc.ac.in

Updated in Mar 2019

Version Changes

i) 1.00: First version

ii) 1.01:

a. Fixed several typographical errors.
b. Expanded the introduction section to include contact information & safety network.
c. Added more information on HF and chemical safety
d. Added section on glassware safety in general safety section
e. Edited and moved safety checklist to appendix
f. Added section on special precautions in chemical safety section.
g. Added section on heated devices in Fire safety.

Contents

1 Introduction

The purpose of this manual is to make all users of IISc facilities aware of safety and emergency protocols (do's and don'ts) that must be followed. The aim is to give you general safety guide lines. While it does cover a wide variety of hazards -- chemical, electrical, biological, etc. – the document does not (cannot) cover all possible hazards. Please use your discretion and more importantly common sense. Remember that the ultimate responsibility of conducting a safe experiment resides with the experimenter himself/herself. ***Consistent violation of safety protocols or willful neglect of safety would result in strict penalties that include probations, fines, and in extreme cases disciplinary action.***

The Institute works with several hazardous materials and equipment. The institute and government allow us to operate with considerable autonomy, trusting us to maintain highest levels of safety. We need to sustain this trust by maintaining a safe working environment. Furthermore, safety is an important part of any training in research. Potential job givers, be it industry or academia, expect a certain awareness about safety. This is especially true for leadership positions where project managers are responsible for the safety of their whole group.

1.1 Safety Principles

The four essential principles of safety are:

1. Follow Rules
2. Personal Responsibility
3. Trust structures more than people
4. Respond to Emergencies

They are discussed below:

1.1.1 Follow Rules

Safety may mean different things to different people, sometime because of ignorance and sometime because of lack of sufficient forethought. To prevent confusion, this manual clearly defines standards for safe work practices. These rules need to be followed by everyone in IISc, both in letter and spirit, even if they sometime appear burdensome and/or pointless (trust us there is a reason for everything). ***Remember practicing safety means doing things the right way, not the quick way.***

1.1.2 Personal Responsibility

The primary responsibility for safety rests with the individual. A responsible, considerate worker with an understanding of the working of the laboratory, its equipment, basic chemistry, common sense, and an instinct for self-preservation will have little trouble with laboratory and chemical guidelines or chemical safety. The staff cannot oversee or supervise operations all the time. Under these conditions, any inconsiderate user can endanger his or her own as well as other's safety. Most problems, incidents and violations in the laboratory are the result of haste. Haste makes waste

Concern for safety must also include others. All hazards should be clearly labeled in a manner that it easily understood by others, e.g. use warning notes/labels extensively. One should act responsibly in the event of an accident, e.g. pull the alarm to warn others. Finally, unsafe behavior should be confronted everywhere, e.g. remind your friend to wear safety glasses. IISc is an open-access laboratory and ***safety is your responsibility.***

1.1.3 Trust structures more than people

No matter how careful they are, people often make mistakes. An effective safety policy does not rely on people but relies on systems to reduce the probability of accidents. Prior to beginning any project or process, it is essential to think about all that potential hazards – all the things that can possibly go wrong. Focus should be on reducing the probability of all the hazards by intelligently designed safety precautions. Try to seek solutions that are inherently faulty tolerant, i.e. "idiot-proof". "I will be careful with chemicals" is a not an "idiot-proof" safety precaution, chemical-resistant gloves are.

Safety precautions also include learning how to store, handle and dispose all hazardous materials. Experiments should only be conducted in designated area with proper ventilation wearing appropriate safety accessories. Equipment should be well maintained with periodic scheduled inspections.

1.1.4 Respond to Emergencies

Everyone must be prepared to respond quickly and effectively in an emergency. Become familiar with the work area, available exits, and safety equipment such as eyewash stations, fire extinguishers, sinks, spill kits, and first aid boxes. Just a few moments spent in training could save a life during an emergency.

1.2 Office of Laboratory Safety and Environmental Health (OLSEH)

OLSEH is the institute body in-charge of all safety aspects at IISc. OLSEH office has a team of experience and trained personnel who are available to consult on a safety issue. OLSEH is a repository of information on best practices. If you are unsure of something, contact them. If you have a safety issue that does not have an obvious solution, contact them.

Finally, OLSEH is the executive arm of Safety Committee. OLSEH office has the right to conduct spot audits, seek information, regulate procedures and policies, and in extreme cases recommend disciplinary action. Please make it a point to respond to any request from the OLSEH office.

Contact information of OLSEH office:

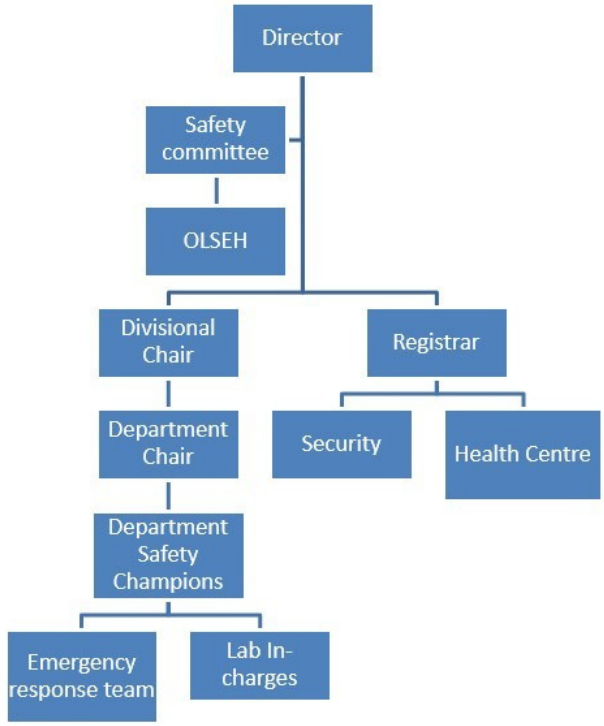
Safety Officer
Office of Laboratory Safety and Environmental Health (OLSEH)
Indian Institute of Science,
Old Digit building Room No-25,
Near Choksi Hall, Bangalore-560012
P: +91 80 22933199
E: safety@iisc.ac.in
W: https://olseh.iisc.ac.in/

1.3 The Safety Network

All departments and Centres have a designated Department Safety Champion. The updated list of Safety Champions can be obtained from the OLSEH website (https://olseh.iisc.ac.in/safety-network/overview-2/). The Safety Champion is the primary contact point for any safety related issue or concern in a department. If indicated, these reports will be confidential.

Safety Committee which is the apex body on all laboratory safety matters. If OLSEH or Safety Champion is unable to resolve your issue, feel free to contact the Safety Committee at SafetyCommittee@iisc.ac.in.

If all fails, you are also welcome to escalate matters to the Registrar, Divisional Chairs or Director.



2 General safety

This section describes some practices which are basic or fundamental to safety in any laboratory where potential hazards exist. Following these simple, somewhat “common sense” rules are important. They will save you from most of the common accidents that happen in laboratory.

2.1 Safety Practices

1. Each lab should have a designated lab-in charge who is responsible for day-to-day enforcement of safety protocols. Each lab will also have a faculty associated with it who is ultimately responsible for safety in the lab.
2. Known and anticipated hazards are considered for all materials or equipment being used. Before using unfamiliar chemicals, equipment, or new products, please read the labels, material safety datasheets (MSDS) and/or user manuals. If in doubt, do some research on the issue and/or discuss it with an authority.
3. Training should be provided for all new lab users. Training of existing users must also be provided when new hazards are introduced into a lab, e.g. during introduction of new substances, processes, or equipment.
4. Only proper equipment, in good condition, should be used. Before trying something very different from an equipment’s intended use, please talk to the lab-in-charge.
5. Boxes, chairs, cartons, shelves, chairs with wheels, or anything else that is not a ladder, should not be used as a ladder.
6. Emergency equipment (e.g. fire extinguishers, emergency eyewash/shower units, etc.) should be unobstructed, clearly visible, and in good working condition.
7. First aid kits are available in quickly accessible, visible and designated places. Ensure that first-aid kits have not expired.
8. Eating, drinking, or applying cosmetics near hazardous materials (radioactive, bio-hazardous, or chemical) is not permitted. Since all labs in IISc count as hazardous, ***NO FOOD/DRINK SHOULD BE ALLOWED INSIDE THE LAB.***
9. Food and drinks should not be stored in the refrigerator or freezer used to store hazardous materials. Refrigerators storing hazardous materials should have a clearly visible label saying, “No food or drinks” (see appendix for a sample).

Figure 1: No eating, drinking, or munching in the lab. Food in lab refrigerator

10. All labs need to fill, update and periodically review the “Laboratory Hazard Sheet” (see appendix) and post it on the laboratory door. To conform that the sheet is current, the lab in charge much sign and date the sheet.
11. All labs must maintain a working landline which is kept near the door.
12. All labs must maintain a list of emergency contact numbers posted very near the phone at eye level. The emergency list should include cell phone numbers of the faculty in charge, the lab in charge, and other regular lab users. The emergency list should also include the number for the IISc health centre, the campus security, as well as the local police and the fire station.
13. Follow Buddy system. Never work alone in a lab, especially at night and during weekends. Buddy is a fellow lab-user who is working close enough to notice if you are in any distress. Friends on cell-phone, in offices, or hostels don’t count.

2.2 Good Housekeeping Practices

1. Work areas are kept uncluttered and are cleaned upon completion of operations or at the end of each workday. This is particularly important for areas with hazardous materials and equipment.
2. Floors are maintained free from tripping, slipping, and falling hazards (e.g. cords, cables, wires, equipment, and tools).
3. Spills are attended to immediately and thoroughly.
4. Emergency equipment and controls are not blocked
5. Hallways and stairways are not used as storage areas.
6. Workbenches and shelves are not overloaded with unused equipment, chemicals, or other materials.

2.3 Personal Care

1. Maintain personal cleanliness, so that hazards don’t affect you after you leave the lab.
2. Confine long hair and loose clothing when in the laboratory to keep them from catching fire, dipping into chemicals, or becoming entangled in moving machinery. (http://www.nytimes.com/2011/04/14/nyregion/yale-student-dies-in-machine-shop-accident.html?_r=0)
3. Avoid wearing dangling jewelry. These can reflect light from lasers or get caught in moving parts.
4. Avoid wrist-bands, rakhees, rings and wrist-watches, and other wrist ornaments. These may become contaminated with chemicals, react with chemicals, or be caught in the moving parts.

5. Remove laboratory coats and gloves before you leave the laboratory to prevent spreading contamination to other areas.

Figure 2: Important personal safety rules

2.4 Personal Protective Equipment (PPE)

Protective clothing and equipment safeguard against harmful chemical spills on the body, inhalation, projectiles etc. You are responsible for wearing the proper protective gear according to the activity you are doing in your lab.

2.4.1 Eyes

1. Understand the difference between safety glasses, chemical splash goggles and face shields. The first is for mechanical hazards, the second for liquid hazards and the third for extra safety when handling bigger hazards.

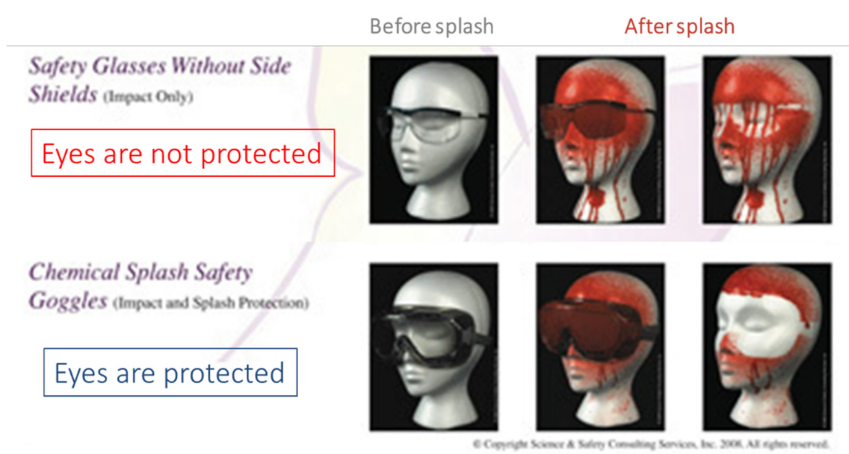


Figure 3: Difference between safety glasses and chemical splash safety glasses. From AirClean Systems

2. Eyes are the most easily injured external organ, so whenever in the vicinity of sharp objects, rapidly moving machines, hot material, or flying particles, safety glasses with side shields must be worn. In fact, it is strongly advisable that safety glasses be worn in the lab at all time.
3. Eyes are also covered with blood capillaries, so they can quickly absorb many harmful chemicals. Splash goggles must be worn when there is danger of splashing chemicals.

4. When working with large amount of chemicals (e.g. 4-liter bottles) or in vicinity of explosive/implosive hazards (e.g. vacuum systems with glass jars), a face shield with safety or splash goggles offers maximum protection.
5. Prescription lenses in spectacles do not provide enough protection. In fact, unless they are shatter resistant, they are hazardous on their own. People who need to wear prescription glasses must wear safety-glasses/splash-goggles over their prescription glasses.

Safety Glasses

- Protects from mechanical and impact hazards
- Must be work in all other labs
- There are no labs in IISc that do not need these

Chemical Splash Goggles

- Protects from liquid hazards
- Needed in any lab that *stores* chemicals
- Wear even if you are personally not working with chemicals

Face Shields

- Protects from voluminous hazards
- For fuming or extremely dangerous chemicals: HF, liq. N2, etc.
- Need to be work OVER splash goggles

Figure 4: Difference in use cases between safety glasses, splash goggles, and face shields

2.4.2 Hands

6. Gloves need to be worn anytime you are handling something in the lab.
7. Ensure that there is no gap between the end of the lab coat sleeve and the glove wrist.
8. Gloves are worn to prevent contact with toxic or biological agents, burns from hot or extremely cold surfaces or corrosives, or cuts from sharp objects. Several types of safety gloves are available, each for specific hazards. For adequate protection, select the correct glove for the hazard in question (see for example http://www.ansellpro.com/download/Ansell_7thEditionChemicalResistanceGuide.pdf).
9. Chemicals will eventually penetrate all glove materials. Change gloves periodically to minimize penetration.

10. Wash hands after leaving the lab even if you were wearing gloves. Long term exposure to even minuscule amounts of toxin can have very adverse effects on your health. Such chronic exposures are very hard to diagnose or detect. Prevention is the only option.

Figure 5: Always wash hands after lab work.

Figure 6: Common gloves their use case

2.4.3 Body and Feet

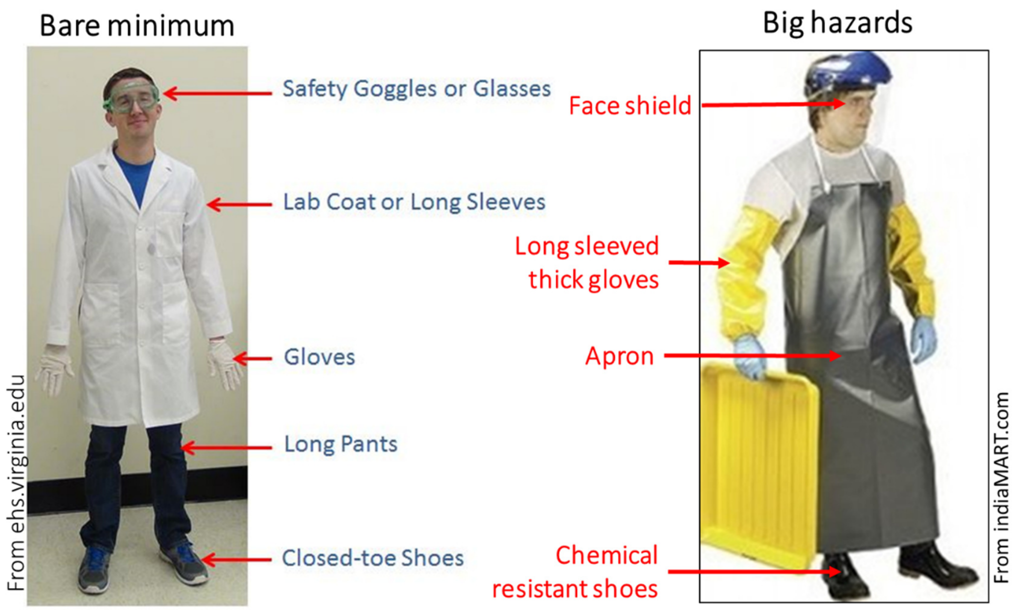
11. Clothing can prevent small chemical from damaging skin. Cover unprotected skin whenever possible. No shorts. Only wear full-length trousers, salwars, etc.
12. Aprons or laboratory coats must be worn especially when handling chemicals.
13. Wear stable hard-toe shoes in lab area to protect feet from chemical splashes and sharp objects on the floor. No slippers, sandals, or high heels. No bare feet.

Figure 7: Only closed-toed shoes allowed in labs.

2.4.4 Breathing Apparatus

14. Proper respirators (self-contained breathing apparatus) must be used whenever there is a chance to inhale hazardous chemicals, gases or nano-particles.
15. Proper respirators (self-contained breathing apparatus) must be used whenever hazardous gas cylinders are being installed/changed.

2.4.5 Summary



2.5 Glassware safety

Accidents involving glassware are a leading cause of laboratory injuries. These can be avoided by following a few simple procedures. In general, be certain that you have received proper instructions before you use glass equipment designed for specialized tasks that involve unusual risks or potential injury.

16. Handle and store glassware carefully so as not to damage it or yourself.
17. When inserting glass tubing into rubber stoppers, corks or when placing rubber tubing on glass hose connections, protect hands with a heavy glove or towel.
18. Substitute plastic connections for glass whenever possible to decrease the risk of injury. Use glassware for vacuum work that is designed for that purpose.
19. When dealing with broken glass wear hand protection when picking up the pieces. Use a broom to sweep small pieces into a dustpan and store glass pieces in a designated bin for broken glass.

3 Chemical & Biological Safety

A wide variety of hazardous chemical and biological agents are used in IISc laboratories. Therefore, it is required to undergo proper orientation to be aware of possible hazards/accidents.

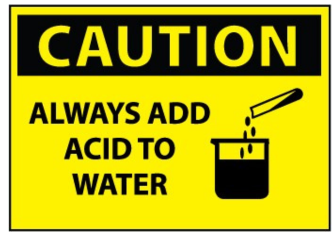
Figure 8: Learn to read MSDS. Maintain a file with hardcopies of MSDS

3.1 Basics

1. Before a researcher begins to work in a laboratory, he/she must be made aware of potential hazards (chemicals, lasers, autoclaves, etc.) associated with the laboratory by the lab in-charge.
2. All researchers are responsible to teach themselves about the hazards posed by the chemicals in their vicinity. If using a material, the researcher should also know the safe way to store, handle, and dispose-off the hazardous chemical. If you do not know, ask someone who does or read the MSDS.
3. All labs are expected to maintain a clearly-labeled folder with hard copies of MSDSs of all the chemicals in the lab. The folder must be stored in a visible location, preferably near the door. This serves as the inventory of chemicals stored in labs.
4. Material Safety Data Sheets (MSDSs) must be reviewed for product specific handling, storage, and disposal information.
5. Become familiar with the location of fire extinguishers, spill kits, and first-aid boxes in your area. Familiarize yourself with their use. All laboratories with heavy hazardous chemical use must have access to a spill kit.
6. Before finishing ensure that the work bench and work areas are clean and that all waste chemicals are properly removed and disposed. Any chemical that are to be leftover must be clearly labelled. There should also be a note with the user name, phone number, and expected time of return.
7. All chemical bottles must be properly labeled. The manufacturer's label is best, as it usually contains a great deal of information about health and physical hazards. If the contents are being stored in another container, the contents need to have the IISc chemical label (see Appendix or download from [OLSEH website]).

Figure 9: Learn to read hazard symbols

8. All chemical work must be done inside fume hoods. Do not open chemical bottles outside fume hoods.
9. Chemical and biological waste should be segregated, labeled (using IISc Waste Label, see Appendix or download from OLSEH website), and appropriately disposed-off.
10. It must be reemphasized, that no set of rules can substitute for common sense and a professional attitude toward laboratory safety.
11. As much as possible, limit the amount of chemicals in the lab. Buy moderate amount of chemicals that can be consumed in near future. Don't let chemical waste pile-up.
12. Don't mix incompatible chemicals. Certain compositions, like organic solvents and acids, are explosive.
13. Date chemicals when received and opened. Unstable chemicals, like ethers, are unstable. Over time they tend to form explosive peroxides.
14. Never add water to acid. Always add acid to water.



3.2 Special Precautions for Hazardous Chemical Usage

3.2.1 Hydrogen Fluoride

Hydrofluoric acid, HF, presents a significant hazard for personal injury. It is available in 40% concentration, diluted, and as the active component of buffered HF, Buffered Oxide Etch. It is widely used in the semiconductor processing for etching oxide films. HF is a very hazardous chemical. It is colourless and odourless, so indistinguishable from water. At the concentrations used in the laboratory, HF "burn" is initially painless. A victim may not even notice a splatter. When exposed to skin on hands, arms, or face, the acid diffuses in and starts to silently eat away the flesh. The fluoride ion is not consumed in this process. Due to solubility, the ions keep penetrating deeper and deeper, until they reach the bone. At this time the victim feels excruciating pain. Unfortunately, by this time it is too late to reverse the considerable tissue damage. At some point, it enters the blood stream, and scavenges Ca ions all over the body. This severely affects the ionic chemistry of the nervous system. If left untreated, exposure is fatal. Be very careful with HF. Err on the side of caution.

1. HF must only be used in the designated extracted wet benches (chemistry laboratory and staff clean room).
2. Apron, gloves, and a face shield should always be worn when handling these chemicals.
3. If there is inorganic fluorides in lab, there should be a 2.5% calcium gluconate ointment nearby to treat burns.
4. Contact trauma centre immediately, if you think you have been exposed.

3.2.2 Volatile Solvents, e.g. Acetone

Highly volatile solvents, like acetone, are flammable with a low flash point. So, they can be ignited even at a low-temperatures. They present a significant fire hazard, so must be managed.

1. Flammable solvents must only be transported in chemical buckets. A spill of a gallon bottle of acetone could cause a catastrophic fire or explosion.

2. Highly volatile solvents should only be used inside hoods.
3. Never use volatile solvents near a hot plate. Spilled solvent can be ignited by the hot plates. The resulting fire could easily be drawn up into the exhaust ducts, again with catastrophic consequences. See below: https://www.bhaskar.com/rajasthan/jhunjhunu/news/rajasthan-news-fire-in-serial-lab-a-scientist-and-student-suspect-feared-chemical-caused-more-heat-due-to-accident-054508-3888079.html
4. Spilled solvents can react explosively with oxidising agents, e.g., peroxides, nitric acid. Spilled solvents should be contained immediately with chemical spill kits. Seek help as required.

3.2.3 Chlorinated Solvents

Chlorinated solvents (chlorobenzene, trichloroethylene, and methylene chloride) are used in various resist processes. Their exposure is particularly hazardous, causing cancer, organ damage, etc. They should not be mixed with normal solvents in waste bottles. There are separate waste bottles for chlorinated solvents. As with most solvents, they can be readily absorbed through the skin.

3.2.4 Peroxides

All peroxides are oxidizers. Considerable energy is released when they react with common materials. Peroxide can also be unstable and explode. Extreme care should be used in mixing solutions containing peroxides. Peroxides are incompatible with all forms of organic solvents. The class of organic peroxides is even more dangerous. Please read MSDS before handling peroxides.

3.2.5 Inhalation hazards

Inhalation hazards, are often not obvious and hence, overlooked, even though the consequences of inhalation are can be quite serious.

1. Toxic or flammable substances that can be airborne (e.g. gases, vapours, dusts, fumes or mists) should not be used in unventilated areas. In the absence of adequate ventilation, air contaminants can build up to levels that pose health or flammability hazards. As much as possible, use such materials in fume hoods.
2. Some specialized equipment are capable of producing airborne hazards fumes, dust, or mist. For e.g. physical vapor deposition systems (sputtering, evaporation, etc.); sand-blasters; grinders, low-melting point metals; solids that sublime at low-temperature; etc. This hazards is compounded if the same equipment are used to handle materials that are toxic. Care must be taken to reduce exposure while using these equipment or toxic materials. Consider using gas masks, respirators, etc.
3. Gases are another common source of inhalation hazard. There are gasses, like H2S, which occur naturally and can be tolerated in small amounts. Hence, there is a tendency to discount their severity. This is a mistake. Always refer to the MSDS to know the exact amount of allowed exposure; instantaneous and chronic. When such information is not available, err on the side of caution.

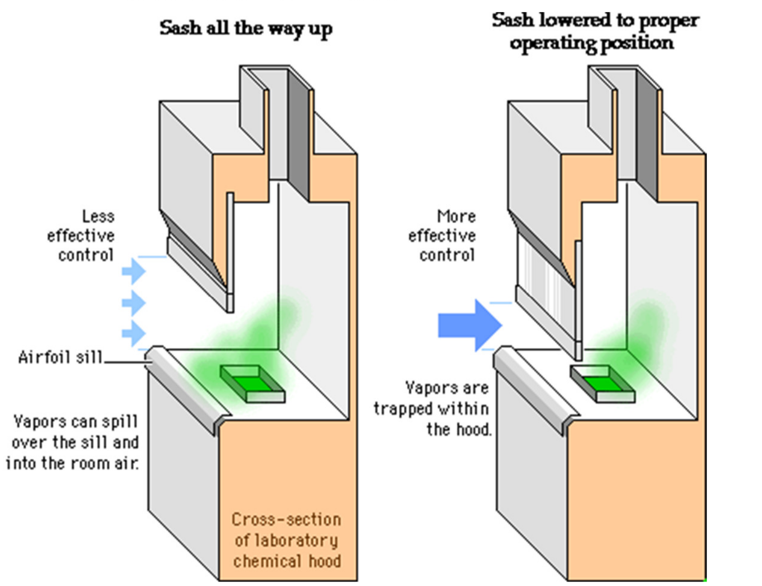
3.3 Chemical Hood Usage

1. Hoods use air-flow to reduce exposure to fumes. Check the anemometer to ensure good air flow before using a hood.

2. Don't do anything that obstructs air-flow in the fume hood. E.g. don't store chemicals or cover vents.
3. Keep the sash of hood as low as possible. This prevents the vapors from back-flowing.
4. Chemicals must be placed at least 6 inches inside the face of the hood.
5. The user should always remain outside the hood. Never peer inside.

From Dow Corning Safety Presentation

From Univ. of Waterloo



From www.tarleton.edu

Figure 10: Good practices to follow while working with fume hoods. Never put your head inside. Don't use hoods as storage. Keep sash as low as possible.

3.4 Chemical Transport, Storage, and Usage.

1. As much as possible, limit the storage of flammable and corrosive chemicals in the lab.
2. Some chemicals, such as ethers, have recommended storage time limits. Chemicals stored beyond their limit date may form explosive peroxides, which can detonate when removing a cap, agitating, dropping, scraping, etc. Upon arrival, these containers should be marked with the date placed in storage and an expiration date based on manufacturer's recommendations. Many manufacturers include an expiration date on the product label.
3. Flammable materials should be stored in flammable material storage cabinets. Storage outside of the cabinet should be limited to materials used in the current process and must be returned after use to the appropriate storage cabinets. Leaving chemicals on benches or working areas is hazardous and is not acceptable. Plastic cabinets are designed for corrosion

resistance and used for storing acid and other corrosive materials. Acids and other corrosive chemicals in the chemistry laboratory maybe stored under the fume hoods.

4. All cabinets must be labelled by chemical class (e.g. flammable liquids, acids, oxidizers) to ensure chemicals are suitably segregated.
5. Store the four classes of chemicals, acids, bases, solvents and oxidizers, separately. If there is an issue of space, solvents and basses can be stored together, and acids and peroxides can be stored together. However, chemicals which can react violently or emit hazardous fumes when mixed, should not be stored near each other. E.g. oxidizers and flammables must never be stored together.
6. Acids, bases and oxidizers must be stored with a secondary containment (to contain the spill in case the first container ruptures). Corrosion resistant plastic trays are a low-cost option for secondary containment.

Figure 11: Secondary containment

7. Large bottles and bottles containing toxic, flammable, or corrosive liquids should be stored on shelves below eye level (maximum 5 feet). Corrosive materials can cause severe tissue damage and are particularly injurious to the eye.
8. Volatile or unstable materials may be stored in a flammable rated refrigerator only in properly sealed containers. Never store flammable solvents (ether, benzene) in the refrigerator in open containers (beakers).
9. Food or drink should never be stored in a laboratory refrigerator or freezer. A “No food/drink” (see appendix) is required on all laboratory refrigerators.
10. Some chemicals may degrade certain container materials. Always check for compatibility. For example, hydrofluoric is incompatible with glass. Inorganic hydroxides are best stored in polyethylene containers. Some organic solvents will soften cheap plastic, so they should be stored in fluorocarbon or glass bottles.
11. Don’t carry chemicals in hands. Transport chemicals in bottle carriers, carts, buckets, etc.

Figure 12: Safe transport of chemical requires trays, buckets and bottle carriers,

These are available in stockrooms.

12. Label all open chemical bottles samples with the contents, owner's name, and date of preparation. Commercially obtained samples should be dated on the day they were opened.

13. Be careful with materials that may form peroxides (diethyl ether, tetrahydrofuran, dioxane). Opened containers of these materials should be discarded within one year of opening. All such containers should be dated upon receipt and upon opening.
14. Never leave an unlabeled bottle of "something" behind when you depart. Everything should be labelled with the Chemical label (See Appendix or OLSEH website).

3.5 Waste Segregation & Disposal

By law, we are required to dispose waste as pollution board rules. We also have a moral obligation to maintain the environment. All lab waste is prima-facie a hazardous waste that must be segregated and disposed appropriately. To avoid difficult and potentially costly waste disposal problems, a procedure should be in place to assure all materials are labeled and unneeded chemicals disposed of properly.

1. Material should be placed into compatible storage containers with secure screw-on tops and labeled with the “IISc Waste Label” (see appendix).
2. In general waste must be stored in the type of container in which the component materials were purchased (glass, plastic or metal). However, metal cans should not be used for acidic

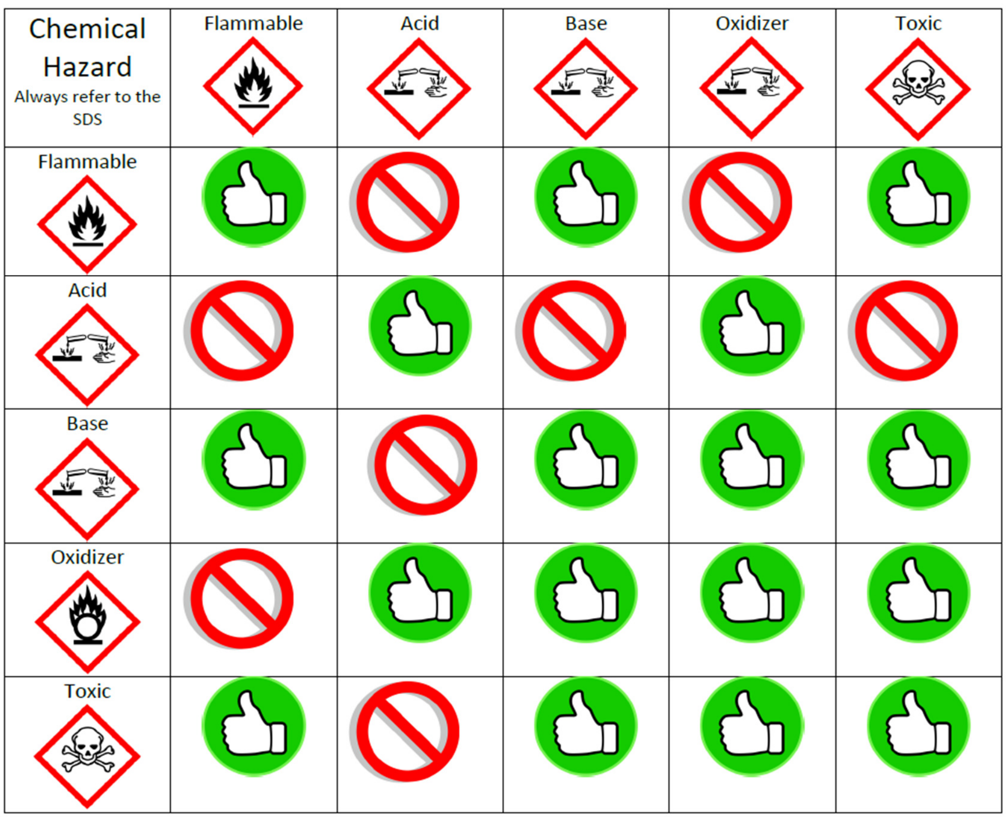


Figure 13: Chemical waste compatibility. From uhs.viginia.edu

and corrosive solutions (alkali, acid, etc.). Also, as much as possible avoid glass containers for storage as they can shatter easily.

3. Small amount of waste can be collected in the labs. Once a month, lab in-charges are required to collect all the waste and bring it to the waste collection shed (next the utility building). Only labelled and segregate waste will be collected so please make sure all the rules of segregation and labelling are followed. No mystery chemicals please.
4. Hazardous waste needs to be segregated and disposed in the following manner to comply with the institute waste management policy.

Figure 14: General chemical waste disposal guidelines. From Wikimedia.org

3.5.1 Chemical segregation

1. Acids + solvents mixture can spontaneously ignite. Never store/leave a solvent + acid mixture in the lab unattended. If you do happen to make such a solution, segregate it and take it outside of the building to the waster shed.
2. Acidic waste with fluoride ions must be collected separately in plastic containers, e.g. dilute hydrofluoric acid, ammonium fluoride and buffered-oxide etch.
3. Acidic wastes which contain toxic metal salts (Cr, Pb, etc.) cannot be buried in a chemical landfill, so must be collected separately.
4. Acid waste that does not contain metallic toxins or fluoride and have a pH>4 can be disposed into the drain with copious amounts of water
5. Acid waste that does not contain metallic toxins or fluoride and have a pH<4 must be separately collected in plastic containers. IISc does not allow individuals to neutralize acids.
6. Acids + oxidizers react and evolve gas. So unattended acids+oxidizer mixtures present an explosion hazard -- in extreme cases plastic bottle can burst spraying acid everywhere. Fresh acids+oxidizer mixtures must be collected separately and kept inside the fume hood for 1 day. This allows time for the reaction to complete and gasses to escape. Nitric acid is both a strong acid and an oxidizer so solutions containing HNO_3 it should be treated as an acid+oxidizer.

7. Solvents + oxidizer mixture can also spontaneously ignite. Never store/leave a solvents + oxidizer mixture in the lab unattended. If you do happen to make such a solution, segregate it and take it outside of the building to the waste shed.
8. Base + solvent mixtures also evolve gasses. So unattended base+oxidizer mixtures present an explosion hazard -- in extreme cases plastic bottle can burst spraying base everywhere. Fresh base+oxidizer mixtures must be collected separately and kept inside the fume hood for 1 day. This allows time for the reaction to complete and gasses to escape.
9. Solvents must be separately collected in plastic or metal containers, e.g. benzene, ether, ethyl acetate, acetone, alcohols, hydrocarbons, etc.
10. Non-toxic basic waste with a pH<10 can be disposed into the drain with copious amounts of water
11. Basic waste with pH > 10, must be separately collected in plastic container. IISc does not allow individuals to neutralize bases. If they do not have any oxidizer, bases can be stored with solvents.

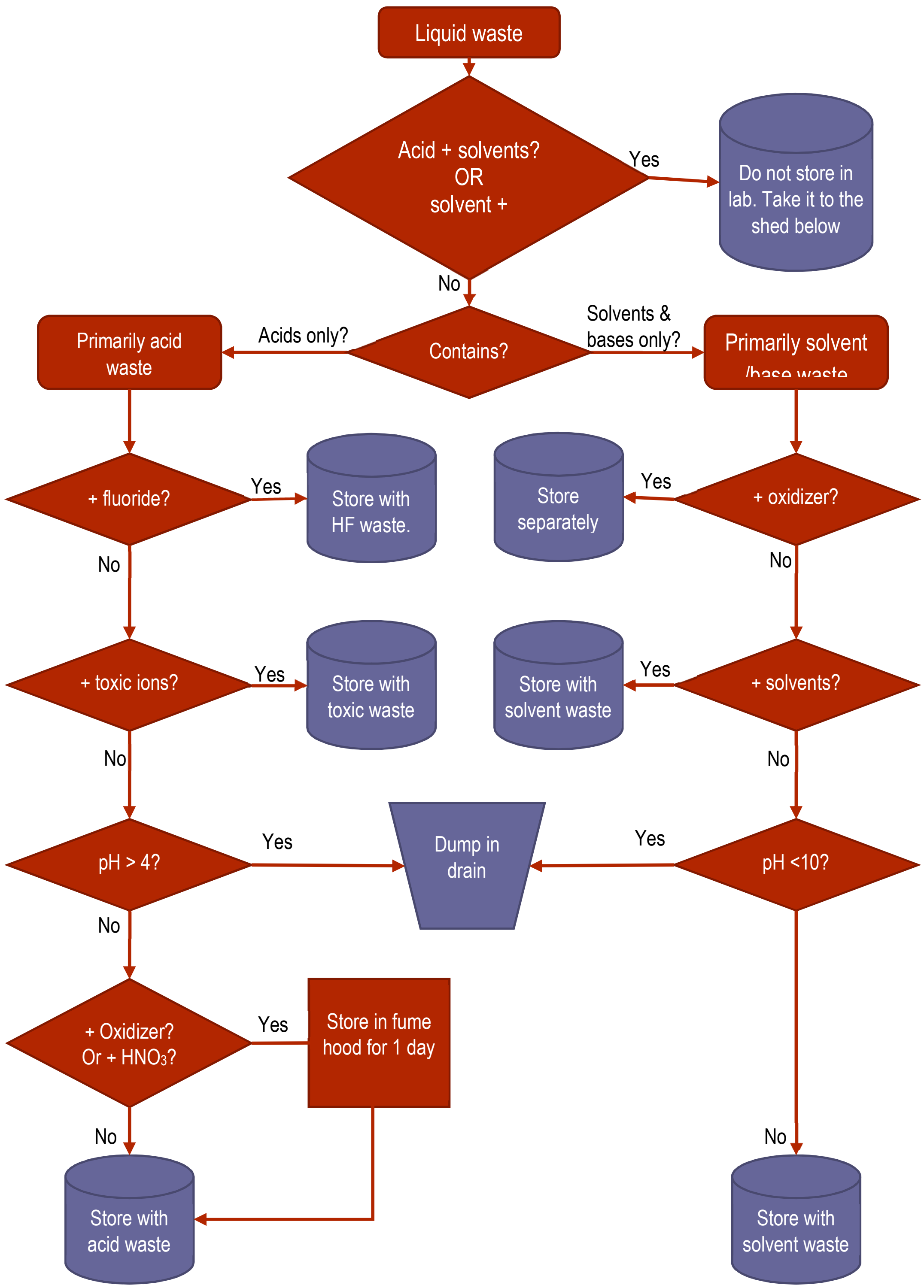


Figure 15: Flow-chart of liquid chemical waste segregation. When in doubt, segregate.

3.5.2 Bio-Waste segregation

1. The dry waste, i.e. napkins, blood-stained wipes, etc. can most go to a Red bin that must be labelled “Bio-waste”. This will be disposed-off as dry medical waste.
2. Sharps, such as needles, must be disposed in red-colored hard containers. These must be labelled as “Bio-waste: Sharps”.
3. Wet waste, such as blood or tissue/bacteria cultures, can be diluted with sodium hypochlorite solution (final concentration 0.5%) and disposed down the drain. If the waste includes other toxic materials, such as acids, bases or liquids between pH of 4-10, then please bottle the waste and bring for monthly waste collection to the shed next the utility building.
4. All dead-bodes, e.g. dead rats, must be stored in dedicated refrigerators. Currently we cannot process dead-bodies. Labs producing such waste must contact the Bio-departments and come with an individual waste-management plan.

Solid bio-waste	Sharps	Wet waste	Carcasses
• Napkins, blood-stained wipes, etc. • Same as sanitary waste	• Syringes, needles, etc. • Sharp boxed labelled bio-waste	• Blood or tissue/bacteria cultures • Diluted with 0.5% sodium hypochlorite solution & disposed down the drain	• Dead rats, animals, etc. • Store in dedicated freezers • Dispose separately

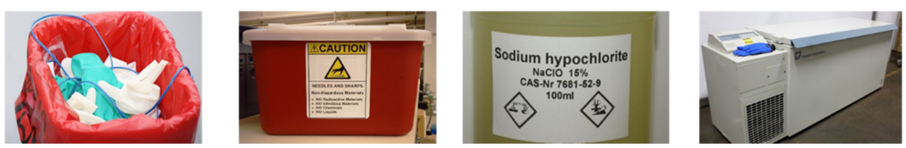


Figure 16: Bio-waste segregation

3.5.3 Radioactive waste

All radioactive waste must be disposed in an AERB mandate pit. For details, please see section on radiation safety.

4 Fire and Electrical Safety

The best defense against fire is to prevent the fire from starting. Everyone is responsible for fire prevention and for knowing how to handle a fire emergency.

4.1 Precautionary procedures

1. Be aware of ignition sources in the laboratory and service areas (open flames, heat, electrical equipment).
2. Always store flammable liquids in appropriate cabinets.
3. Do not store incompatible reagents together. Some combinations, e.g. acids and organic solvents, are explosive.
4. Do not store unstable chemicals, like ethers, for extended periods of time. They tend to form explosive peroxides. If you have an old sealed bottle, don't open it. Date chemicals when received and opened. This allows tracking.
5. Make sure that all electrical cords are in good condition and all electrical outlets are earthed. Remain out of the area of a fire or incident if you are not in position to help.
6. Locate the fire exits, fire alarms and extinguishers in your laboratory. Each laboratory should be equipped with extinguishers. See the following section to learn about different types of fire extinguishers.
7. Maintain adequate walking space in laboratory, minimum of 2 feet and unobstructed access to exits.
8. Ensure adequate ventilation around objects that heat up (e.g.: lamps, CPUs, etc.).
9. Avoid long-term storing carton boxes, thermocole and other plastic/packaging materials. These are a major cause of fire incidents.
10. Papers, binders and manuals must be stored in enclosed containers/cupboards, away from hot objects.
11. Do not block access to fire escape routes, even outside of the laboratory. For example, the stairs should be free of debris, nothing should be stored in front of fire hoses, etc.
12. Keep your workspace neat and tidy. Oily rags, carton boxes, waste or papers improperly stored are common causes of spontaneous combustion. Store these materials in covered metal containers.
13. Ensure that fire extinguishers are serviced and inspected regularly.
14. Keep a small handy fire extinguisher near flammable chemicals and organics.

4.2 Electrical Safety

1. Access to electrical equipment (e.g. plugs and switches) should be maintained free from obstruction.
2. Electrical apparatus is equipped with ground plugs or is properly grounded.
3. Make sure that live terminals are not exposed to direct or indirect touching in all switches and outlets.
4. Ground fault circuit breakers are used as needed.
5. Two-pin appliances (un-grounded) are not within a 5-foot radius of flammable materials.
6. All current transmitting parts of electrical devices are enclosed.
7. Electrical connections are not handled with wet hands or when standing in or near water.
8. Safety devices (e.g. fuses) on electrical equipment are not bypassed.

9. Electrical equipment is disconnected from electrical outlets or circuits when being adjusted, lubricated, moved, or cleaned.
10. Do not disconnect power supply by pulling or jerking the cord from the outlet. Pulling the cord causes wear and may cause a shock
11. Electrical plugs, cords, and extension cords are maintained in good condition.
12. Power strips and extension cords use is kept to a minimum and cords are as short as possible. Daisy chain of surge protectors are not a replacement of permanent plug points. If additional plug points are required, ask BMS. Overloaded power boards can not only damage the devices that are plugged in, they can cause electric shocks and even start fires.
13. Cords are placed in areas where they are not exposed to physical damage. They are not run through doorways or ceilings or placed under carpets.
14. Don't splice extension cords or electrical cords without properly insulating the junction with insulation tapes.
15. Always make sure that you don't overload an electrical outlet (e.g. don't connect a 15A device to a 5A socket). If an outlet is overloaded it may lead to fire in that circuit. •
16. Never try to extinguish an electrical fire with water (this can result in electric shock if the burning wires are still live); use only the proper fire extinguisher.

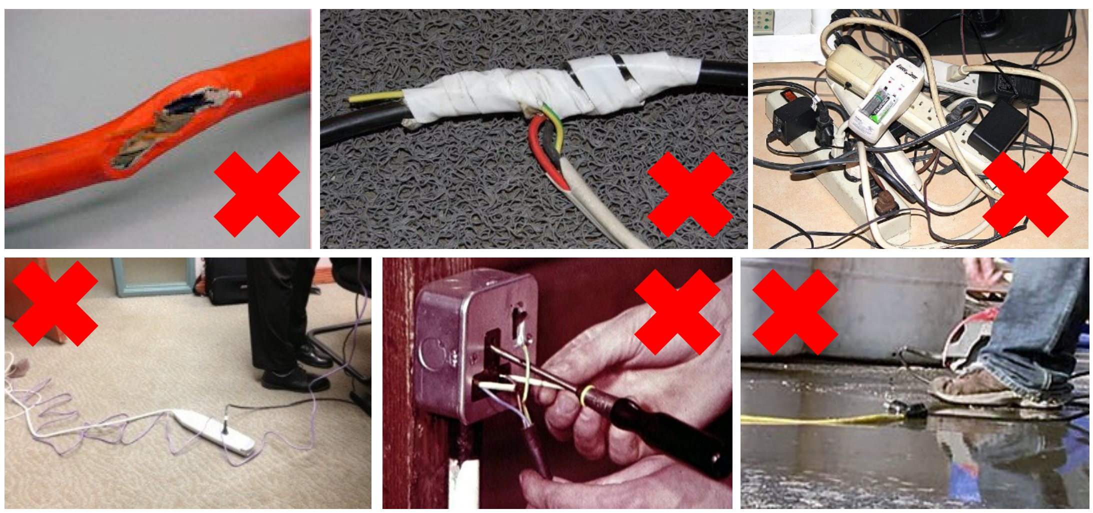


Figure 17: Avoid these unsafe practices

4.3 Heated Devices

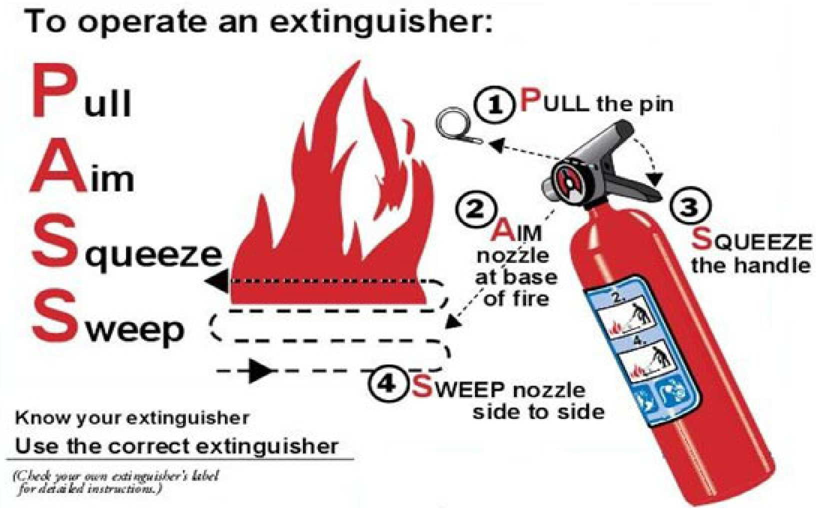
Electrical devices that supply heat in laboratories include: Hotplates Tube & Box Furnaces Heating Mantles Hot-Air Guns Oil Baths Improper use of any one of these could result in fire or burns to the user.

1. Check to see if the unit has an automatic safety shutoff in case of overheating.
2. Note the condition of electrical cords and have them replaced as required.
3. Make sure the apparatus has been maintained as required by the manufacturer.
4. Check to see that all heating units in use without automatic shut-off have been turned off before leaving an area for any extended period of time.

5. Flammable or combustible solvents should not be used in a heated bath or placed near the bath. Oil baths must always be housed in a chemical fume hood.
6. Make sure there is adequate ventilation around an heated equipment.

4.4 Fire Extinguisher

1. All must learn how to operate a fire-extinguisher. Mnemonic PASS is often used to describe fire extinguisher usage.



2. Use correct type of extinguisher. Lab must have extinguishers for all type of hazards present inside it.

Type of Fire	Material	Class	Method to Extinguish
Ordinary combustible material	Wood, paper, textiles, etc.	A	Water, Foam spray, ABC powder, Wet Chemical
Flammable liquids	Oils, solvents, grease, paint, etc	B	Foam spray, ABC powder, Carbon Dioxide
Flammable gasses	SiH_4, GeH_4, organic vapors, etc	C	ABC powder
Metal	Magnesium, Aluminum, Sodium, Potassium, Zirconium, Titanium etc.	Metal	Special metal extinguishers. DO NOT use ordinary extinguishers found in the building or else a violent reaction may result.
Electrical	Short circuit, Hot electrical components, lightening discharge etc	-	Powder type, Carbon dioxide

Following illustration shows different sources of fire and the right type of extinguisher to be used (http://www.vcmfiresafety.com/images/)

Symbol found on Fire Extinguishers and what they mean	Water	Foam Spray	ABC Powder	Carbon dioxide	Wet Chemical
A Wood, Paper & Textiles	✓	✓	✓	✗	✓
B Flammable Liquids	✗	✓	✓	✓	✗
C Flammable Gases	✗	✗	✓	✗	✗
Electrical Contact	✗	✗	✓	✓	✗
F Cooking Oils & Fats	✗	✗	✗	✗	✓

4.5 Fire Safety infrastructure

All departments are required to periodically evaluate the fire-preparedness. Depending on the hazards, the department my be required to invest in layers of Fire-alarms, sprinklers, fire-detectors, etc. General guidelines are:

1. All multi-storied building must have an operational fire hydrant loop. The primary responsibility of maintaining the hydrant loop rests with the departments.
2. All building with significant gas, electrical, or chemical hazards must have a sprinkler system. The maintenance and testing of the system are the receptibility of the departments.
3. All departments must have an evacuation plan and emergency response team (ERT). Details are in Section on Emergency Response.

5 Laser & Radiation Safety

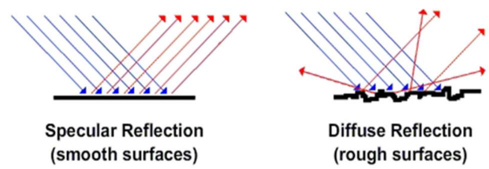
5.1 Laser Safety

LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. A laser produces an intense, highly directional beam of light. High power lasers can cause damage to eyes and skin and in extreme cases cause blindness and burns (see Fig).

Figure 18: Damage caused to eyes (retina and cornea) and skin by high-power lasers.

5.1.1 Exposure to Laser

1. **Primary beam:** Direct hit/exposure from primary beam. This is the most hazardous.
2. **Specular reflection:** Exposure from laser hitting a shiny/smooth surface. This can be as hazardous as the primary beam.
3. **Diffuse reflection:** Exposure from a rough object. Typically, this is less serious but also hard to detect and hence dangerous.



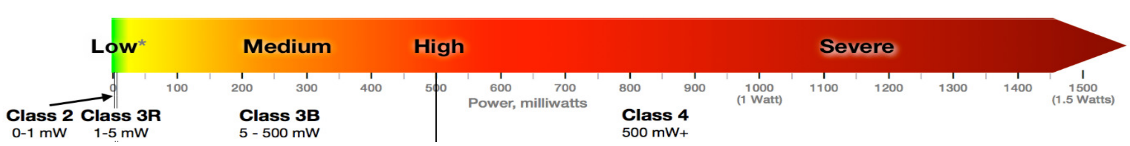
5.1.2 Laser Classification

Lasers can be classified based on power and wavelength. For details please see
http://www.rli.com/resources/articles/classification.aspx

http://www.lasersafetyfacts.com/laserclasses.html

5.1.3 Visible lasers (400-700 nm)

Based on their hazard, laser sources are categorized into classes. Modern ANSI/IEC classification is preferred (See table below) over older FDA Roman numeral classification. (Class I-IV). Class 1 lasers have the lowest hazard while Class 4 lasers create the greatest hazard. Exposure is typically expected to be <0.25 s. It is expected that the user will have a aversion response, which will prevent longer exposures.



Class	Procedure	Training	Eye Exam	Energy	Hazard
1	Not Required	Not Required	Not Required		Typically, when laser is not accessible. Non-hazardous to eye
1M	Not Required*	Not Required*	Not Required		Hazardous with collecting optics, e.g. with microscopes.

2	Not Required	Not Required	Not Required	0 – 1 mW	Hazardous only when person overcomes aversion response
2M	Not Required*	Not Required*	Not Required		Hazardous with collecting optics and/ Class 2 hazard
3R	Not Required	Not Required	Not Required	1 – 5 mW	Hazardous when person overcomes aversion response or uses optics
3B	Required	Required	Suggested	5 – 500 mW	Direct beam eye hazard. No serious injury from diffuse reflection to eye or to skin
4	Required	Required	Suggested	> 500 mW	Hazard to eye & skin from direct, specular or diffuse reflection. Fire hazard

In general, we should never come in the way of laser light. Calculations have been done to estimate distance at which lasers with typical beam-spread are very dangerous. Calculations for some typical lasers are given in the table below. However, please remember that lasers are still dangerous beyond these distances. Do not stare at a laser, ever.

Laser	**Eye hazard distance or Nominal Ocular Hazard Distance (NOHD)** at which beam power <2.5 mW/cm2	**Flash blindness distance** at which beam power <100 μW/cm2	**Skin burn distance**	**Fire hazard distance**
Class 2: 0.99 mW 532 nm	14 m	67 m	0.9 m	0.6 m
Class 3R: 4.99 mW 532 nm	32 m	149 m	2.1 m	1.4 m
Class 3B: 499 mW 532 nm	158 m	747 m	10.5 m	7.0 m
Class 4: 5W 532 nm	250 m	1182 m	16.6 m	11.0 m

5.1.4 Non-Visible lasers (>700 nm)

Non-visible laser do not generate any aversion reflex. This significantly increases the possible of longer exposure which can be very dangerous. Even at lower powers there is a significant risk of losing eyesight.

The damage to the eye, depends on the laser wavelengths (see Fig below). Wavelengths between 380-1400 nm are transmitted by the cornea and absorbed in the retina. On the other hand, wavelengths longer than 1400 nm are strongly absorbed in the cornea and do not reach the retina for low exposures. Absorption in cornea also does damage, but since damage to retina is often irreparable, lasers from 380-1400 nm are considered more dangerous. Non-visible laser (700-1400 nm) are even more dangerous because there is no aversion response.

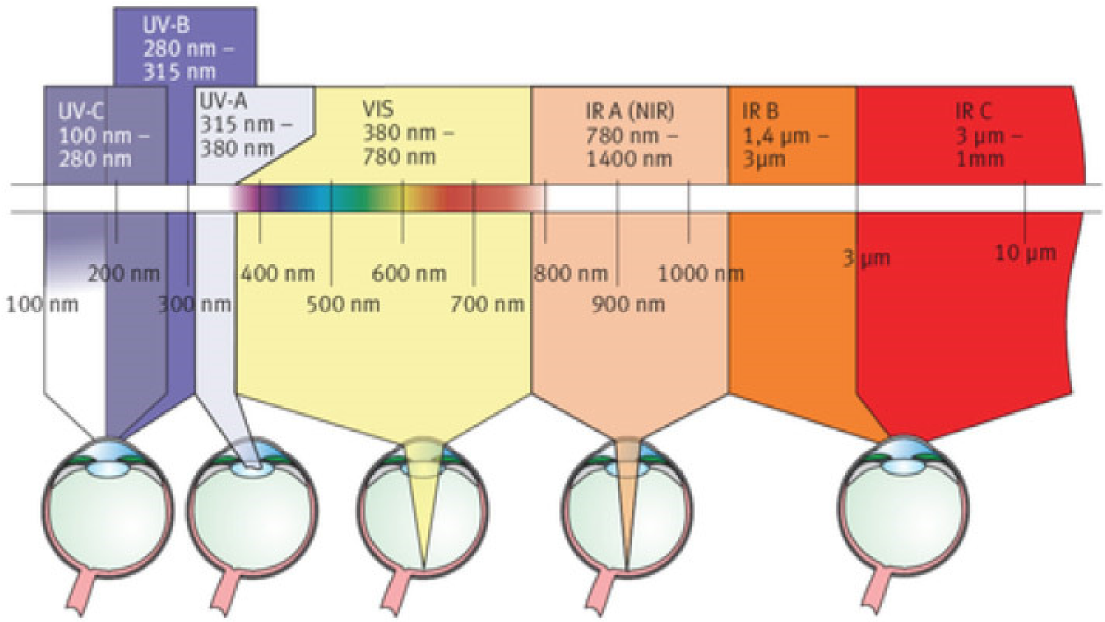


Figure 19: Effect of laser wavelength on various parts of the eyes. Retina damage is irreparable. Cornea and lens damage is extremely painful.

5.1.5 Laser Protection

Appropriate laser eye protection and other personal protective equipment must be worn while working around lasers, especially for Class III and IV lasers. The type of protective equipment will be based on the class and wavelength of the laser involved.

Laser safety glasses have lens that reduce the intensity of an incident laser beam. Glasses are commonly rated ANSI Z136 standard, which correlates safety with transmittance. Transmittance is specified in terms of optical density (OD). Higher OD = higher level of protection. It is important to select appropriate OD level based on the power level of the laser.

OD	Transmittance	OD	Transmittance
0.0	100%	5.0	0.001%
1.0	10%	6.0	0.0001%
2.0	1%	7.0	0.00001%
3.0	0.1%	8.0	0.000001%
4.0	0.01%	9.0	0.0000001%

$$OD = \log_{10} \frac{1}{T}$$

$$\Rightarrow 10^{-OD}$$

OD = Optical Density
T = Transmittance (decimal)

As per ANSI Z136

Unfortunately, the correct choice of laser safety eyewear depends upon many local factors other than power that cannot be evaluated remotely, including the beam path, laser parameters, and lab environment, we can't recommend a specific eyewear for your application. Always, discuss your needs with your supervisor. EN 207 is more recent and complete standard that accounts for some of these effects. We highly recommended that it be used instead of ANSI Z136.

Laser Mode	Engraved Symbol	Pulse Duration
Continuous Wave (CW)	D	>0.25 s
Pulsed Mode	I	>1 µs - 0.25 s
Giant Pulsed Mode	R	1 ns - 1 µs
Mode Locked	M	< 1ns

Figure 20: EN207 standard for laser safety glasses.

Wavelength	Laser Mode	Maximum Power Density (P) or Maximum Energy Density (E)	Minimum Scale Number (LBn)
180 - 315 nm	D	$1\times10^{n-3}$ W/m^2 ($1\times10^{n-7}$ W/cm^2)	$\log_{10}(P)+3$
	I and R	$3\times10^{n+1}$ J/m^2 ($3\times10^{n-3}$ J/cm^2)	$\log_{10}(E/3)-1$
	M	$3\times10^{n+10}$ W/m^2 ($3\times10^{n+6}$ W/cm^2)	$\log_{10}(P)-10$
>315 - 1400 nm	D	$1\times10^{n+1}$ W/m^2 ($1\times10^{n-3}$ W/cm^2)	$\log_{10}(P)-1$
	I and R	$5\times10^{n-3}$ J/m^2 ($5\times10^{n-7}$ J/cm^2)	$\log_{10}(E/5)+3$
	M	$1.5\times10^{n-4}$ J/m^2 ($1.5\times10^{n-8}$ J/cm^2)	$\log_{10}(E/1.5)+4$
>1400 - 1000000 nm	D	$1\times10^{n+3}$ W/m^2 ($1\times10^{n-1}$ W/cm^2)	$\log_{10}(P)-3$
	I and R	$1\times10^{n+2}$ J/m^2 ($1\times10^{n-2}$ J/cm^2)	$\log_{10}(E)-2$
	M	$1\times10^{n+11}$ W/m^2 ($1\times10^{n+7}$ W/cm^2)	$\log_{10}(P)-11$

Recommended tutorial:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=762&gclid=CjwKCAjwxZnYBRAVEiwANMTRX43hAarpf9593iJz1XDNc0r9f8tDevT-VHrvm4JbxGZ1XAEcZRMAYBoC-vYQAvD_BwE

5.1.6 Best Practices

1. Never look directly at the laser beam or light-pump source.
2. Do not allow any object which could cause reflections in or along the beam, such as spherical buttons, screw heads, or jewelry, in the working area.
3. Keep a high general illumination level where lasers are in operation to cause contraction of pupils and reduced hazard.
4. Post warning signs on laser equipment and on the doors of labs/rooms that have laser equipment.
5. Always wear personal protective glasses whenever lasers are in the same room, irrespective of whether you are using that laser or not.
6. High-power lasers must be partitioned into separate work-spaces, with wall-to-floor partitions. No safety eyewear works for all wavelengths, so simultaneously using lasers with different wavelengths in the same work-area is dangerous.
7. Good quality laser protection goggles often have relevant protection levels listed on them. Before using a laser equipment, always check if the protection is adequate.

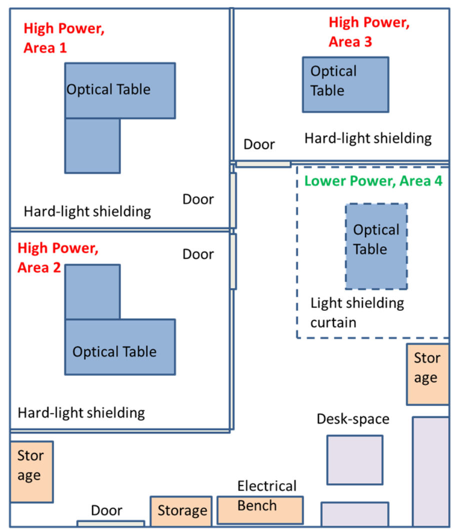


Figure 21 Layout of the high-power laser lab at CeNSE, showing separate workspaces. Courtesy Prof. Supradeepa

Figure 22 Safety goggles with safety rating

5.2 Ultraviolet safety

1. All radiation of wavelengths shorter than 350 nanometers should be considered dangerous.
2. Protective safety glasses with UV absorbing lenses should be worn when there is even a chance of accidental eye exposure.
3. Skin exposed to strong UV radiation can receive painful burns, analogous to sunburns. So be completely clothed while working with UV radiation.

4. UV lights are often used to sterilize the room/area. In such cases please make sure the room had tinted/plastic windows, such that UV light does not escape.

5.3 X-Ray and Nuclear Safety

1. Follow ALARA = As Low As Reasonably Achievable. This means reduce time, distance, and use shields to reduce your exposure to radiation.
2. Laboratories with X-ray sources should have notices posted outside the door.
3. According to GoI policy, all X-ray equipment must be registered with the AERB.
4. All X-ray sources are expected to be shielded by safety enclosures so that no users are exposed to X-rays.
5. Staff regularly working with X-rays must have thermoluminescent dosimeter (TLD), a type of radiation dosimeter that measured personal exposure.

Figure 23: Radiation safety rules.

6. There should be automatic interlocks that shut off the sources when the safety enclosures are open.
7. Disabling or dismantling the interlocks is expressly forbidden.
8. AERB Directive No. 01/2011 lays down the maximum permissible exposure limits. These must be explicitly followed. The limits are different for operator (staff), trainees (students, post-docs, INUP) and general public (staff, admins, visitors, etc.).

9. During pregnancy, maximum limits are even more stringent. Equivalent dose to embryo/fetus must be < 1 mSv.

Occupational Worker	Apprenticeship & Trainee	Public
• an effective dose of 20 mSv/yr running averaged over five years • an effective dose of 30 mSv in any year; • an equivalent dose to the lens of the eye of 150 mSv in a year; • an equivalent dose to the extremities (hands and feet) of 500 mSv in a year • an equivalent dose to the skin of 500 mSv in a year;	• an effective dose of 6 mSv in a year; • an equivalent dose to the lens of the eye of 50 mSv in a year; • an equivalent dose to the extremities (hands and feet) of 150 mSv in a year and • an equivalent dose to the skin of 150 mSv in a year	• an effective dose of 1 mSv in a year; • an equivalent dose to the lens of the eye of 15 mSv in a year; and • an equivalent dose to the skin of 50 mSv in a year.

Figure 24: Maximum permissible exposure limits, as per AERB directive no. 01/2011

5.4 Acknowledgement

We thank Ms. Roopa Prakash (PhD, CeNSE) for authoring the section on laser safety.

6 Cryogenic safety

Cryogenic liquids are liquefied gases that are maintained at very low temperatures. These liquids are gases at normal temperatures and pressures. Since these liquids are extremely cold and can expand to very large volumes of gases they are a safety hazard. The following guidelines should be followed while working with cryogenic liquids.

Liquid Oxygen	-297.3 °F (-183 °C)
Liquid Nitrogen	-320.4 °F (-195.8 °C)
Liquid Argon	-302.6 °F (-185.9 °C)
Sublimation Point	
Liquid CO_2	-109.3 °F (-78.5 °C)

6.1 Types of Cryogenic Liquids

1. **Inert Gases:** Inert gases do not react chemically to any great extent. They do not burn or support combustion. Examples of this group are nitrogen, helium, neon, argon and krypton.
2. **Flammable Gases**: Some cryogenic liquids produce a gas that can burn in air. The most common examples are hydrogen, methane and liquefied natural gas.
3. **Oxygen**: Many materials considered as non-combustible can burn in the presence of liquid oxygen. Organic materials can react explosively with liquid oxygen. The hazards and handling precautions of liquid oxygen must therefore be considered separately from other cryogenic liquids.

6.2 Types of Cryogenic liquids Container

Cryogenic liquids are shipped and used in thermally insulated containers. These cryogenic liquid containers are specifically designed to withstand rapid temperature changes and extreme differences in temperature.

1. **Liquid Dewar Flasks:** Liquid Dewar flasks are non-pressurized, vacuum-jacketed vessels, somewhat like a "Thermos bottle". They should have a loose fitting cap or plug that prevents air and moisture from entering, yet allows excess pressure to vent. Flasks containing helium, hydrogen and other low- boiling liquids have an outer vessel of liquid nitrogen for insulation.
2. **Laboratory Liquid Dewar Flasks:** Laboratory liquid Dewars have wide-mouthed openings and do not have lids or covers. These small containers are primarily used in laboratories for temporary storage.

Figure 25: (left) Liquid dewar flasks of different sizes. (right) laboratory liquid dewar flask

3. **Liquid Cylinders:** Liquid cylinders are pressurized containers specifically designed for cryogenic liquids. This type of container has valves for filling and dispensing the cryogenic liquid, a pressure-relief valve with a frangible (bursting) disk as backup protection. Never remove/disable the safety valves, otherwise the tank can explode with disastrous consequences. Please read: http://blogs.sciencemag.org/pipeline/archives/2006/03/08/how_not_to_do_it_liquid_nitrogen_tanks

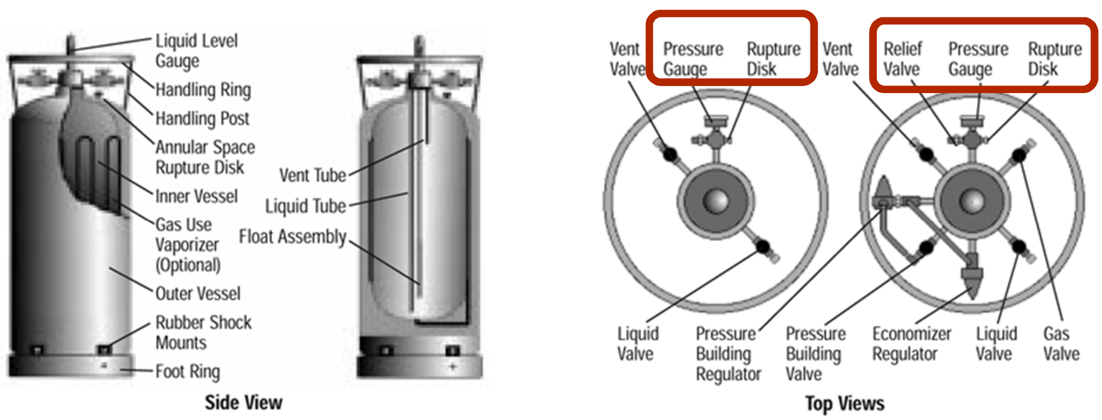


Figure 26: (left) cros-section liquid cylinders. (right) top view of the liquid cylinders showing the safety relief valve and rupture disks

6.3 Health Hazards of cryogenic liquids

There are three groups of health hazards associated with cryogenic liquids: extreme cold, asphyxiation, and toxicity.

1. **Extreme Cold Hazard:** Cryogenic liquids and their associated cold vapors and gases can produce effects on the skin similar to a thermal burn. Brief exposures that would not affect skin on the face or hands can damage delicate tissues such as the eyes. Prolonged exposure of the skin or contact with cold surfaces can cause frostbite. The skin appears waxy yellow. There is no initial pain, but there is intense pain when frozen tissue thaws. Unprotected skin can stick to metal that is cooled by cryogenic liquids. The skin can then tear when pulled away. Even non-metallic materials are dangerous to touch at low temperatures. Prolonged breathing of extremely cold air may damage the lungs. Always handle the cryo liquids with personal protective equipment: face-shield, gloves and apron.

Figure 27 Required personal protective equipment for handling cryogenic liquids

2. **Asphyxiation Hazard:** When cryogenic liquids form a gas, the gas is very cold and usually heavier than air. This cold, heavy gas does not disperse very well and can accumulate near the floor. Even if the gas is non-toxic, it displaces air. When there is not enough air or oxygen, asphyxiation and death can occur. Oxygen deficiency is a serious hazard in enclosed or confined spaces. Small amounts of liquid can evaporate into very large volumes of gas. For example, one litre of liquid nitrogen vapourizes to 695 litres of nitrogen gas when warmed to room temperature (21°C).
3. **Toxic Hazards:** Each gas can cause specific health effects. For example, liquid carbon monoxide can release large quantities of carbon monoxide gas, which can cause death almost immediately. Refer to the material safety data sheet for information about the toxic hazards of a particular cryogen.

6.4 Flammability Hazard of Cryogenic Liquids

Several types of situations exist that may result in a flammability hazard including: fire, oxygen-enriched air, liquid oxygen, and explosion due to rapid expansion.

1. **Fire Hazard:** Flammable gases such as hydrogen, methane, liquefied natural gas and carbon monoxide can burn or explode. Hydrogen is particularly hazardous. It forms flammable mixtures with air over a wide range of concentration (4 percent to 75 percent by volume). It is also very easily ignited.
2. **Oxygen-Enriched Air:** Liquid hydrogen and liquid helium are both so cold that they can liquefy the air they contact. For example, liquid air can condense on a surface cooled by liquid hydrogen or helium. Nitrogen evaporates more rapidly than oxygen from the liquid air. This action leaves behind a liquid air mixture which, when evaporated, gives a high concentration of oxygen. This oxygen-enriched air now presents all of the same hazards as oxygen.

3. **Liquid Oxygen Hazard:** Liquid oxygen contains 4,000 times more oxygen by volume than normal air. Materials that are usually considered non-combustible, (such as carbon and stainless steels, cast iron, aluminum, zinc and Teflon (PTFE),) may burn in the presence of liquid oxygen. Many organic materials can react explosively, especially if a flammable mixture is produced. Clothing splashed or soaked with liquid oxygen can remain highly flammable for hours.
4. **Explosion Due to Rapid Expansion:** Without adequate venting or pressure-relief devices on the containers, enormous pressures can build up. The pressure can cause an explosion called a "boiling liquid expanding vapour explosion" (BLEVE). Unusual or accidental conditions such as an external fire, or a break in the vacuum which provides thermal insulation, may cause a very rapid pressure rise. The pressure relief valve may not be able to handle this increased pressure. Therefore, the containers must also have another backup device such as a frangible (bursting) disc.

6.5 General Rules

1. Always use cryo rated gloves, face-shield, and apron when handling cryo liquids. Cryo liquids should not be handled without open-toed shoes.
2. Handle the cryo liquids safely. This means use of both hands to hold dewar and duct.
3. Never store, transport cryogenic liquids in non-rated containers.
4. Never store cryo liquids above eye level, i.e. above 5 ft.
5. If a safety valve blows up. Please investigate. There is a reason it blew up
6. Never disable, replace or weld shut a safety valve. As irritating as they might be, they keep us all safe

Figure 28: The correct usage with proper protective equipment + use of both hands to hold the tank and tube.

7 High-Pressure Safety

If pressure equipment fails in use, it can seriously injure or kill people nearby and cause serious damage to property. In addition, sometimes the gases are chemically active. The addition of chemical energy makes the tank ticking time bombs that must be safely handled. Please treat gas with due respect.

7.1 Examples of pressure systems and equipment

1. Compressed air systems (fixed and portable)
2. Pipework and hoses
3. Gas cylinders

7.2 General Rules

1. During storage and use, all cylinders need to be clearly labelled. Flammable, toxic, pyrophoric gasses must be distinguished by the color of the tags and stored in segregated areas. Please see the appendix for examples.
2. All gas cylinders need to be chained to the wall. The chain must either be at half height or two chains at 1/3 and 2/3 height. This ensures that the cylinder stays vertical in the event of cylinder valve failure, preventing it from flying through the walls like a missile.
3. Please ensure the fitting/regulators being used are rated for the pressure they are being subjected to.
4. Cylinder must be located away from other hazards. Maintain an exclusion zone around a cylinder as per standard given below.
5. The cylinders come with a valve guard. This protects the cylinder valve in case the cylinder falls. Please keep it on if the cylinder is not being used.

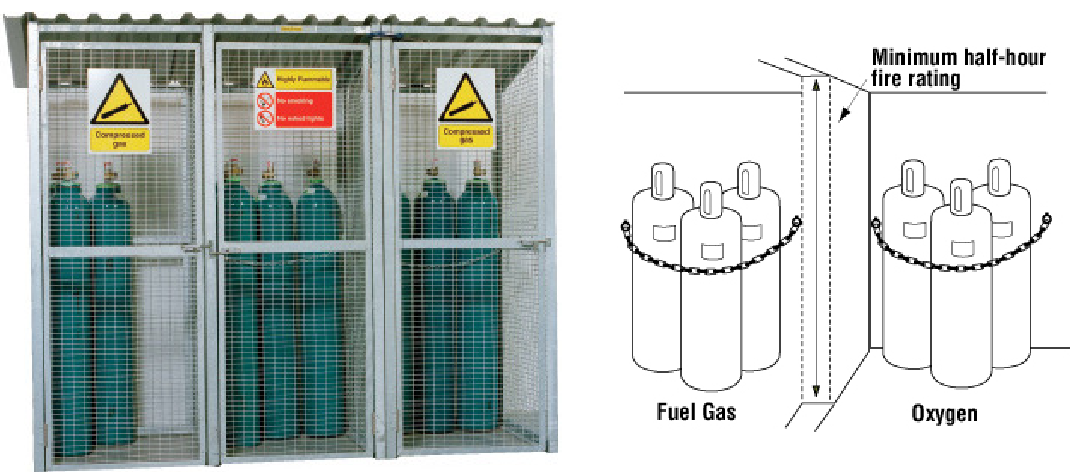
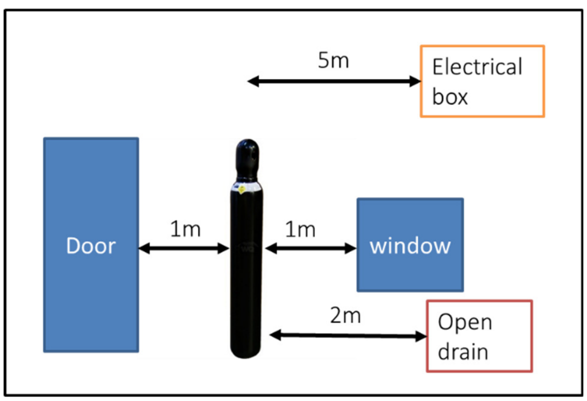


Figure 29: For Long-term storage, segregate cylinders, store them in covered but ventilated cages and keep them chained.

6. Always install the cylinder with an output pressure gauge and shut-off valve. The former makes sure an unsafe pressure is not maintained in the line. The latter is useful in an emergency where the gas supply needs to be turned off.
7. Cylinders must always be moved on carts. Do not roll them horizontally. If handling a gas cylinder manually, you must two people holding the cylinder.

Figure 30: Proper method of cylinder transport. Don't roll the cylinders.



Regulator and valve guard

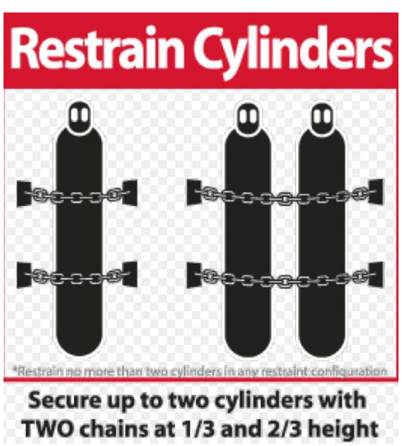


Figure 31: Rules to follow during use. Maintain an exclusion zone around the cylinder. Don't remove valve guards. Use gas regulators. Always restrain cylinders at 1/2 or 1/3+2/3 height.

Gas cylinders chained to wall

8. The spindle valves of tanks come in different designs. On the left is an older design, where there is danger of spindle loosening while the valve is being turned on. There are two threads in series. Opening one can open the other. The probability of this is significantly lower in newer spindle valves (see figure on the right). Request all lab in-charges to do a self-audit on the cylinders in their labs. If they have cylinders with old designs, please get those changed with the more modern ones. I will add his information in the safety manual as well. The squiggly bracket in the picture can be a guide to tell the difference.

Figure 32: Older vs. newer spindle design. Strongly advise all to only accept cylinders with newer spindle design.

7.3 Hazardous gases

Any gas that is categorized as toxic or pyrophoric is a hazardous gas. These are considered significantly more dangerous than compressed gasses and need additional handling.

1. Hazardous gasses need a gas cabinet to be operated safely. Gas cabinet shut off the gas flow in case of alarms or gas leaks. The gas cabinets may be completely automatic or semi-automatic. The need of gas cabinet must be decided on a case to case basis. In general, highly toxic and/or pyrophoric gasses require a gas cabinet.
2. Hazardous gases must only be used with welded, face-seal fittings (VCR® or equivalent). No Swagelok® or other compression fittings. No plastic tubing. In extreme cases coaxial lines are needed. IISc prefers purged coax lines instead of evacuated ones.
3. The design of all gas manifold of hazardous gases must be certified by two faculty members, at least one of whom is the PI.
4. All welded fitting carrying hazardous gases must be He-leak checked.

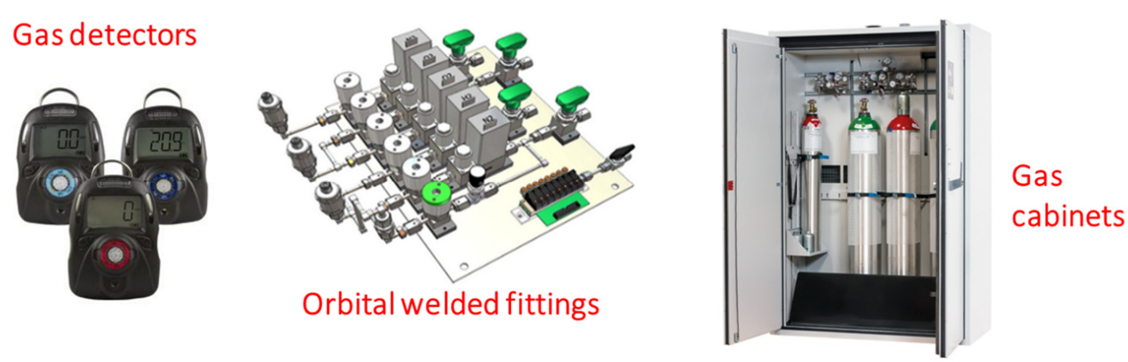
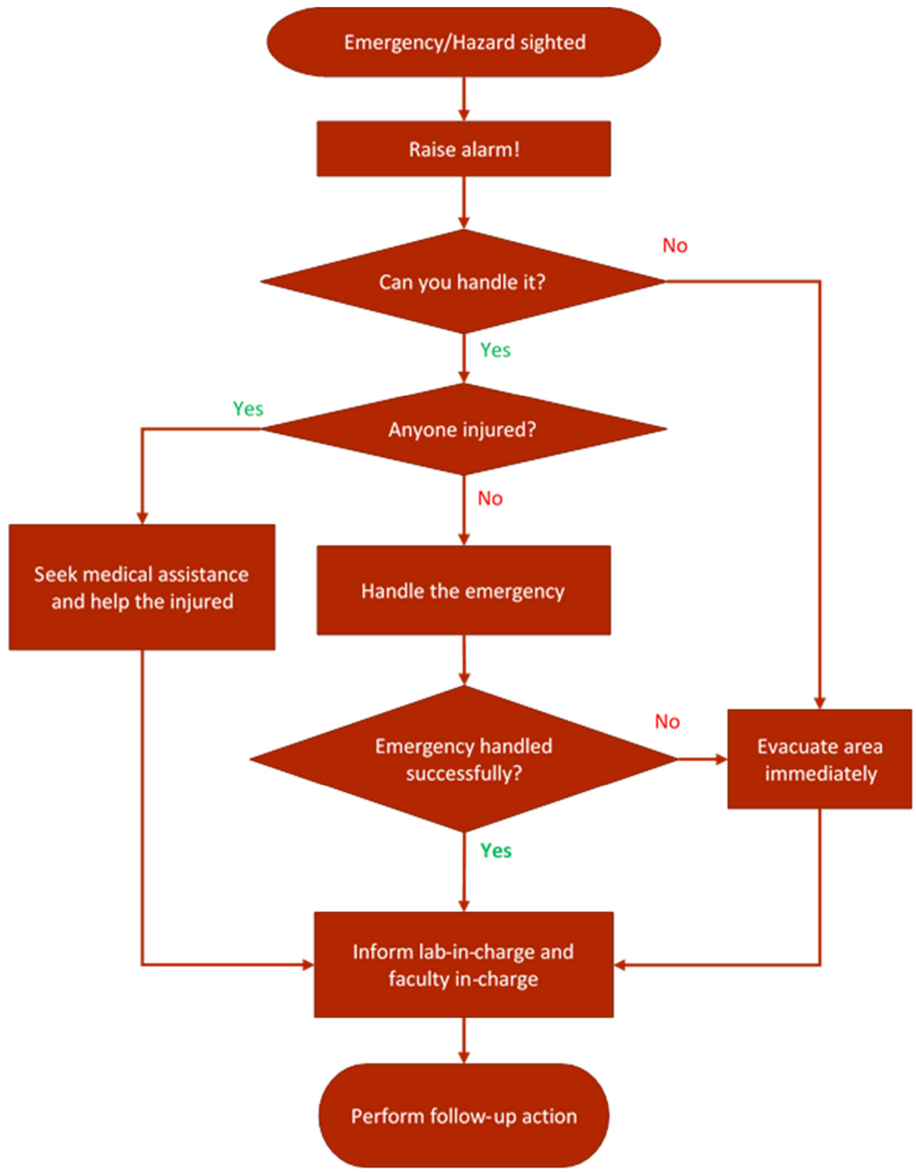


Figure 33: Additional requirement for hazardous gases.

5. Lab facilities with hazardous gasses are supposed to install automatic sensors for detection and warning of harmful gas leaks. Hand held detectors are strongly recommended.
6. Proper respirators (self-contained breathing apparatus) must be used whenever hazardous gas cylinders are being installed/changed.

8 Emergency Response and Evacuation

Using signage and regular safety lectures, all users of a building must know the actions they need to perform if they stumble across an emergency. The response must be contingent on the severity of the emergency. For e.g. smaller fires may require use of fire extinguisher, while gas leaks need a global alarm.



8.1 Emergency evacuation

All buildings are required to have an emergency evacuation plan that allows all occupants to exit the building, establishes chain of command, demarcates responsibilities, and establishes rules of liaising with external emergency services. The primary responsibility of defining the fire exit plan rests with the Safety Champion of the department that administers the building. The safety champion can take the help from OLSEH to formulate the plan. The emergency plan must follow the following guidelines:

8.1.1 Strategy

1. All buildings must have a method to announce a global emergency that mandates evacuation. This can be a simple a public address system or a manual/automatic fire alarm.
2. All buildings must designate a network of emergency exits, and assembly points such that all occupants of a lab can exit the building and reach the safe assembly point within 2 minutes of a global alarm.
3. The number of these exits and assembly points depends on the size and layout of the building.
4. The location of emergency exits, and assembly points must be clearly shown on signage posted at strategic locations, e.g. corridors, break-out spaces, lecture halls, assembly points, etc.
5. Assembly points are where occupants assemble during the emergency. Hence the location of these assembly points must be chosen well. The assembly points must be far from the

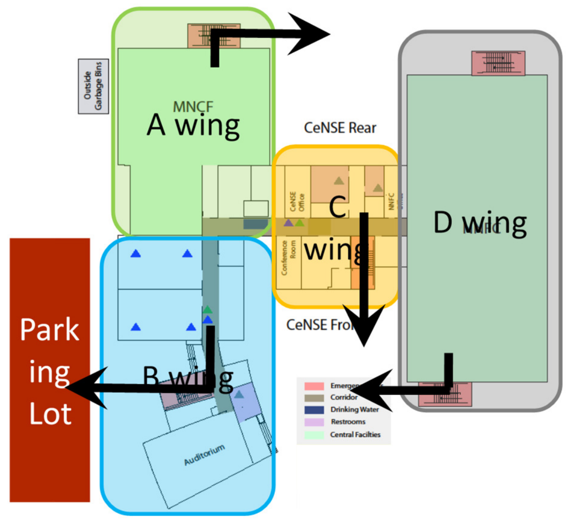


Figure 34: An example of a fire evacuation strategy

Figure 35: Example of an emergency escape route

hazards, e.g. electrical yards, gas cylinders, chemical storage, etc. Assembly points cannot be in the path of emergency vehicles.
6. All labs must identify the route to the nearest emergency exit from each lab ("emergency escape route"). This route must be clearly posted inside each lab. See example.
7. The emergency escape routes cannot include elevators. Only stairs can be used during emergencies.
8. During emergency, emergency vehicles such as ambulance and fire trucks must be able to reach the premises. This requires a suitably wide thoroughfare that is always free of obstruction (i.e. no parked vehicles or bikes or storage). Ideally, the emergency vehicles should have 360° access to the building.
9. None of the doors that are part of the emergency evacuation strategy can ever be blocked or physically locked. They can only be latched or electronically locked, such that they can be opened in an emergency by anyone.

8.1.2 Action on hearing a global alarm

All users of a building must know the actions they need to perform if they hear the global evacuation alarm. For most of the occupants, this response will be an evacuation to an assembly point. Some people might have additional responsibilities, e.g. members of the emergency response team (ERT)

8.1.2.1 Emergency response team (ERT)

ERT is group with the primary responsibility to respond to an emergency. The roles/responsibilities may change with department and associated hazards. At its very basic, ERT is in-charge of ascertaining the validity of the emergency, calling external emergency vehicles, managing the assembly points, liaising with institute and external safety/security teams, and issuing the "all-clear".

1. ERT must be a statutory body in a department, composed of faculty and permanent staff. A part of ERT must be "on-call" 24x7. The composition of ERT must be communicated to the OLSEH by the department Chair. The ERT is assumed to be technically familiar with all the hazards in a department. This might require the ERT to conduct periodic audits in their respective departments.
2. Some multi-storied building may need additional floor-warden who ensures that evacuation orders are being followed in a certain section of the building.
3. Each assembly points must have a designated leader who is in-charge of taking attendance or headcount. This and any pertinent information given by the evacuating public can be escalated to the ERT.
4. ERT is the only one who can issue an "all-clear" after a evacuation. No can enter the building until ERT has issued the all-clear.
5. ERT is the primary contact for institute and external agencies involved in an emergency. ERT is responsible for calling emergency vehicles (or setup a structure such that this happens automatically). Since they are the only people familiar with all the hazards in a department, the ERT is also expected to liaison with the agencies.

8.2 Chemical Spill Response

Based on the chemicals stored and used in the laboratory, lab in charges must anticipate the types of spills that can occur in their respective laboratories. It is their responsibility to obtain the necessary equipment (spill kits, personal protective equipment, and disinfection materials if biological materials are present in the laboratory) to respond to a spill prior to it happening.

1. If the spill is too large, highly toxic, flammable, aggressive, or just scary, please call emergency response, press global alarm and evacuate. The following compounds are considered very hazardous and should not be cleaned by users: aromatic amines, hydrazine, bromine, organic halides, hexamethylphosphoramide (HMPA), carbon disulfide, cyanides, ethers, nitro compounds and nitriles. Users must also not try to contain gas leaks of flammable, toxic or pyrophoric gases.
2. If and only if you can do so safety, attend to injured or exposed personnel and remove them from exposure.
3. Alert people in the laboratory to evacuate. Alert people in the immediate area of the spill and make sure that you are aware of the hazards associated with the material spilled. If the spilled material is flammable, turn off ignition and heat sources.
4. Clean up the spill. Less experienced user should only clean up minor spills (<50 ml). For larger spills, call help of staff or experienced users.
    1. Acids and bases typically need neutralization kits.
    2. In case of a mercury spill use mechanical means or a portable pipette vacuum, do not use house vacuum or a vacuum cleaner. Cover small droplets in inaccessible areas with powdered sulfur. Place the residue in a labeled container and dispose it separately.
    3. To cleanup alkali metal spills, smother with anhydrous sodium carbonate, calcium carbonate, powdered graphite or sand.
5. While cleaning up the spill, have adequate ventilation (open windows, fume hoods on) and proper protective equipment (minimum: gloves, splash goggles, and apron/lab-coat).

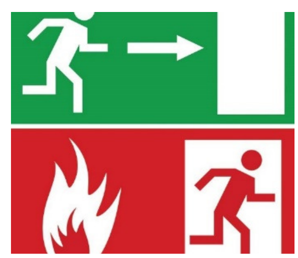
Neutralizing kits

- 10-50 ml of spill
- Experienced student or staff
- Area must be barricaded and labelled

Large spill kits

- For large spills, 0.1 to 50 litres
- Only by trained staff
- Affected lab to be evacuated

Emergency evacuation



- For significant toxic, explosive or fire hazards
- Evacuate building
- Trip fire alarm

8.3 Fire Response

1. If you see fire, evaluate if you are in immediate danger. If you are, raise alarm and evacuate.
2. If the fire is small, try to contain the fire using a fire extinguisher. If you can't, call ERT. The emergency numbers must be near the landline. Give your name, location, nature of the emergency and telephone number.
    a. Once the fire is contained, call the lab in charge and the faculty in charge.
    b. Try to assist any injured people around you. See section below on first aid.
3. If you hear the fire alarm, immediately evacuate.
4. During evacuation:
    a. If confronted with smoke, keep near the floor. Smoke, heat and toxic gases will normally rise to the ceiling.
    b. Do not use elevators, as they might not work during emergency.
    c. Using the nearest emergency exit, exit the building.
    d. Go to the designated safe assembly point
    e. From the assembly point call the lab in charge and the faculty in charge.
    f. Stay at assembly points, until an "all-clear" is issued by the emergency response team.
5. Inform ERT of any hazardous conditions (presence of inflammable/toxic chemicals or gases).

8.4 First-response (First-aid)

First-aid is a specialist activity so it hard to be very specific about exactly what to do. Use common sense. Following points are primarily to sensitize you of the possibilities.

8.4.1 General Injury

Do the following and in this order (unless common sense says otherwise):

1. Call emergency response.
2. If an individual is contaminated or exposed to a hazardous material in the laboratory, do what is necessary to protect his/her life without compromising your own. If you can do so safely, determine the nature of the hazardous material and communicate this information to the attending medical personnel.
3. If the person is in contact with a live electrical circuit, do not touch him/her. Disconnect the power first by turning off circuit breakers or by dislocating the live wire with a non-conducting object.
4. Do not move an injured person unless he/she is in further danger. Unnecessary movement can exacerbate injury. Keep the victim warm and awake.
5. Initiate first aid treatment to the victim if trained or qualified to do so. In the case of severe bleeding, place a paper pad (from first-aid kit) or cloth on the cut and apply firm pressure to control the bleeding.

6. Call the lab in charge and faculty in charge.

8.4.2 Burn Injury

Follow the following steps and in this order.

1. Extinguish fire as quickly as possible, with whatever is available. Still it is wise to know that not all methods are equal.
    1. Most effective method is to immediately deluge the victim with water under a safety shower. Water not only extinguishes the fire but also cools down the body by transporting the heat away, preventing further burns. Of course there should a water source and you should be in a position to drag the victim to the source.
    2. Often quickest option is the “stop, drop and roll” drill. Just make sure to put some damp towels on victim to reduce temperature, once the flame is extinguished.
    3. If water is not available and drop/roll is not practical, blankets, coats, etc. can be used to smother the fire. Remember, try to smother, not fan the flames so they become more intense. Remember even after the flames die down the body continues to suffer damage due to all the trapped heat. So, apply some damp towels, to reduce body temperature.
    4. In extreme cases, fire extinguishers can be used. However, understand the following:
        i. CO2 type extinguishers tend to freeze. So, don’t focus spray on the same place for 10s of seconds. Try to create a blanket of CO2 around the person so that the flames die down.
        ii. Extinguishers are designed to be aimed at the base of a fire. They don’t work well on surfaces, like human body.
        iii. With foam-type extinguishers, you need to create a blanket around the burning person, which is hard and wastes precious seconds.
2. If there is danger of further injury, move the victim. Else let them be.
3. Call emergency response.
4. Immerse the burned area in very cold or ice water until pain not only is relieved but also does not return when the burned area is removed from the water. If the burn cannot be immersed, apply ice cold compresses.
5. After ice treatment, cover the victim with a blanket to keep him/her warm to prevent hypothermia.
6. If the burns are extensive there is a high probability of victim going into a shock, so try to keep the patient awake and calm.
7. Be careful not to contaminate the burned area. Cover the burned area with sterile gauze or a sheet. Do not apply oily ointments, lotions or cleanser to the burned area.
8. Call the lab in charge and faculty in charge.

8.4.3 Chemical Spill on Body

Symptoms of chemical exposure may include: irritation, burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea and vomiting. If you feel any of these contact a trauma center immediately. If you come across a victim of chemical exposure:

1. Remove the victim from contact with the chemical as promptly as possible.
2. Affected areas of the skin should be thoroughly flushed with water (at least 15 minutes) by shower. Do not apply neutralizing or buffering agents. During flushing, goggles should be left on the victim until his head and face have been washed.
    1. Alkali metals (e.g., lithium, sodium, and potassium) should be rapidly removed with a cloth, paper towel or tweezers *before* flushing with water. If any metal on the skin ignites on contact with water, immediately deluge it with cold water.
3. Remove the clothing contaminated with chemicals but do not remove clothing that has burned onto the skin.
4. For fluoride acid spills, use liberal amount of calcium gluconate after washing with water to neutralize the fluoride ions. Use way more than what you think is enough.
5. Call emergency response.
6. Call the lab in charge and faculty in charge.

8.4.4 Eye Injury

1. Try to remove the foreign object, if and only if, it is loose and unattached. Best to do this with a wet piece of clean cotton or with clean water.
2. If the particle is on the cornea or is embedded in the eye, do not touch it.
3. For splashes of chemicals in the eye or exposure of the eye to corrosive vapors, remove contact lenses if necessary and flush the eye thoroughly with water from an eye wash fountain for at least 15 minutes. Eyelids should be forcibly held apart so that the entire surface of the eye may be washed. Never apply a neutralizing solution as first aid.
4. Call emergency response. Transfer the victim to a physician or ophthalmologist immediately.
5. Call the lab in charge and faculty in charge.

8.4.5 Ingestion of Chemicals

1. Call emergency response.
2. Call the lab in charge and faculty in charge.
3. Provide the ambulance crew and physician with the chemical name and other relevant information. If possible, send the container, and/or a label along with an MSDS with the victim to the nearby health center.

8.4.6 Inhalation of Chemicals

1. Do not enter the area if you expect oxygen depletion, explosive vapors or toxic gases.
2. Special equipment must be worn by the rescue party. If you don't have access to the equipment, just call emergency response.
3. Remove the victim from the contaminated atmosphere and move into the fresh air as quickly as possible.
4. Call emergency response.
5. Call the lab in charge and faculty in charge.

4. If possible, identify the substance to which the victim was exposed. Provide the ambulance crew and physician with the chemical name and other relevant information. If possible, send the container, and/or a label along with an MSDS with the victim to the nearby health center.

8.4.7 Unknown

In case the victim is unconscious, unresponsive, or unable to respond; and if you cannot ascertain the type of injury, assume the worst. If the lab has toxic gases, assume gas leak. If the lab has hazardous chemicals, assume chemical exposure. If the lab has lasers, assume laser injury. In all cases priority is your own safety.

1. Evaluate if you can safely enter the lab. If not, then just call the emergency response.
2. If you can enter safely, see if you can help the victim.
    1. If the victim is in danger of continuous exposure, try to remove him.
    2. If the victim is not in danger of more exposure, leave him as is. Unnecessary movement may exacerbate injury.
3. Call the emergency response.
4. Call the lab in charge and faculty in charge.

9 Penalties

Consistent violation of safety protocols or willful neglect of safety would result in strict penalties that include probations, lab closure, and in extreme cases disciplinary action. On observation of a violation by a person/PI, the following steps will be enforced:

1. A white notice will be sent by the OLSEH with a time frame for remedial action based on the severity of the violation.
2. If the violation is still not remedied, a yellow notice will be sent to the User/PI with a requirement for immediate action.
3. In case of non-compliance even after the time frame of the yellow notice has lapsed, a red notice will be sent by the OLSEH followed by a temporary closure of the laboratory/facility if the violation is still not remedied.
4. If it is found that a person(s) has grossly violated this Policy, such an individual will be subject to disciplinary action commensurate with the severity of the violation in accordance with the applicable service rules.

In cases of severe violations requiring immediate remedial action, the OLSEH office will directly issue a red notice to the concerned person.

10Appendix

10.1 Self-Audit Checklist

Building/Dept.________________________ Room__________

Date_________________

Principal Investigator____________________ Audit Performed By____________________

General instructions:

1. Complete self-audit and send to Department Safety Champion.
2. Mandatory signage can be downloaded from OLSEH website or the Department Office.
3. Personal Protective equipment must always be used when working in the laboratory. Check that students are using them.
4. Lab in-charge is responsible for laboratory safety. Lab users should be quizzed on safety rules during the audit.
5. Improper chemical segregation is a common issue. Please check the inventory of chemicals to ensure solvents, oxidizers, acids and bases are segregated.
6. All chemicals must be labelled. Labels can be downloaded from OLSEH website.
7. All chemical waste must be labelled. Labels can be downloaded from OLSEH website.
8. Gas cylinders are also often stored improperly and not tagged. Please check. Tags can be downloaded from OLSEH website
9. Exit doors, including those which open directly from lab spaces into stairwells, cannot be locked during normal business hours. Security measures are allowed after hours, with the approval of the OLSEH office.
10. Electrical cords that have frayed wires or broken insulation present significant electrical shock and fire hazards. Replace or repair an electrical cord found to be in poor condition.
11. Cover plates must be installed on all electrical outlets and switches to prevent accidental contact with electrical wires.

Type	**#**	**Safety checkpoint**	**Yes**	**No**	**NA**	**Remarks**
General	1.	Working telephone				
	2.	Emergency contacts list near telephone at eye level				
	3.	Hazard sheet is filled and current. The sheets must have been signed in the last 6 months.				
	4.	Users are wearing closed toed shoes in the lab. Some labs ask users to take off shoes. In such cases replacement shoes must be provided. No chappals.				

	5.	No evidence of food/drinks being brought inside lab. No tea/coffee cups. No lunch boxes.				
	6.	The lab should look clean and organized. No accumulated junk, like carboard boxes, trash, etc.				
	7.	Has the lab in-charge instituted an orientation program that all new users must go through to get access to the lab?				
	8.	At-least one light is connected to UPS?				
Important Note: Minimize storage of materials in laboratory premises. For example, paper goods, plastic containers, materials stored in boxes and empty containers.						
Fire	9.	Two feet of unobstructed walking space around labs				
	10.	Fire extinguishers (appropriate type) in working order				
	11.	Fire extinguishers are stored at proper and visible places				
	12.	Equipment that heat up during operation have adequate ventilation				
	13.	No exposed electrical wires, broken plugs, broken switches, etc.				
	14.	Power strips are of appropriate wattage (given the load).				
	15.	Large equipment connected to earth.				
Laser	16.	High-power laser (Class 3 and above or invisible) must have warning light outside the door				
	17.	Laser safety glasses, if Class 2 laser of above.				
	18.	High-power laser (Class 3 and above or invisible lasers) must have a separate partition with floor to wall barrier				
Chemical	19.	Chemical containers are labelled properly and contain necessary information. No mystery bottles.				

	20.	Chemicals are stored in appropriate cupboards. No open shelfs, no wooden (flammable) cupboards. Large amounts of solvents need exhausted cabinets.				
	21.	All chemical storage must have hazardous stickers (e.g. corrosive, oxidizer, toxic, etc)				
	22.	All chemical waste must be clearly labelled. There should be appropriate waste disposal facility for all chemicals stored in the lab. E.g. If you have acids, there must be a way to dispose acids, etc.				
	23.	Personal protective eqpt. (Glasses, gloves, aprons, shoes) must be easily accessible, not inside locked cabinets. For liquid hazards need splash goggles, not glasses. For aggressive chemicals, need thick nitrile gloves not thin examination gloves. No latex gloves. Large amounts of chemicals require face shields				
	24.	If corrosive chemicals are used, eye sprays must be nearby,				
	25.	MSDS of all hazardous chemicals are printed out and stored in a file that is easily accessible				
	26.	Acids, bases, oxidizers and solvents, are segregated, either in different cupboards or with secondary containment.				
	27.	All refrigerators used to store chemicals, must have "No food" sign. There should not be any food in any fridge in any lab.				
	28.	Clearly marking on the dustbins to distinguish lab waste (hazardous) and general waste				

	29.	Chemical work can only be done in hoods with proper ventilation				
	30.	Sharps must be disposed in hard containers.				
	31.	Bio waste must be appropriately disposed. Red dustbins for soiled napkins, etc. Blood/cultures can be disposed down the drain but only after hypochlorite treatment (labs should have hypochlorite). Dead bodies must be disposed thru Bio departments.				
High-pressure	32.	Gas cylinders are properly chained to walls, either at half height or 1/3 + 2/3 height. Cylinders must be stored in a tight formation so that they cannot tip. Carts cannot be used for permanent storage.				
	33.	Unused or spare gas cylinders must have valve guards.				
	34.	All cylinders must have tags that identify the contents, status (empty/in-use/full) and person in-charge.				
	35.	All hazardous gas lines must have welded VCR connections. Highly dangerous gasses must have coax connections.				
	36.	Hazardous gas cylinders need gas cabinets.				
	37.	CVD reactors must be connected to functional exhausts.				
	38.	Any lab with hazardous gasses must have sensors to detect that gas. The sensor should be functional.				

Cryo	39.	All labs with cryo liquids must have cryo-rated personal protective equipment. Everyone needs gloves. Large amounts need face shields and aprons also.				
	40.	Cryo cylinders must have safety valves and rupture disks.				
	41.	Cryo liquids can only be handled in rated dewars or flasks.				
Electrical Hazard	42.	Cover Plates in place for outlets and switches				
	43.	No extension cords used				
	44.	Inspect AC filters periodically				
Exits	45.	Illuminated signs working				
	46.	Paths free from obstructions				
	47.	Emergency exits accessible and marked				

Additional Checklist for Chemical Storage and Handling

1. Generally, light-duty and wooden cabinets should not be used. Cabinets units should be securely anchored to the wall.

2. To avoid potential contamination, food should not be stored in refrigerators or freezers designated for chemical storage.

3. Labelling of cabinets by chemical class (e.g. flammable liquids, acids, oxidizers) is essential if chemical storage is to be segregated to avoid incompatibilities, and to identify storage areas for emergency response personnel.

4. Highly toxic gases, such as fluorine, phosgene, and many semiconductor gases, should be stored in ventilated cabinets made for this purpose. In the event of a leak or fire, the gas cabinet would contain and exhaust the gas, protecting the laboratory worker from exposure.

5. Toxic or flammable substances that can be airborne (e.g. gases, vapours, dusts, fumes or mists) should not be used in unventilated areas. In the absence of adequate ventilation, air contaminants can build up to levels that pose health or flammability hazards.

6. Chemical containers should be clearly labelled with at least a chemical name. The manufacturer's label is best, as it usually contains a great deal of information about health and physical hazards. When a chemical is transferred from the original container, the new container should be labelled, as possible.

Small containers may use other means of identification, such as a code or number system referenced to the user's lab notebook.

7. In order to avoid spillage or release of vapors, containers should be closed except when transferring.

8. For optimum performance and containment, a fume hood should have the minimum amount of chemicals or apparatus in it when in use. It is particularly important that the slots or baffles at the back of the hood are unobstructed.

9. Some chemicals may degrade certain container materials. For example, hydrofluoric is incompatible with glass. Inorganic hydroxides are best stored in polyethylene containers. Some organic solvents will soften plastic.

10. Chemicals which may react violently or emit hazardous fumes when mixed should not be stored near each other. Examples include oxidizers and flammables, acids and bases.

11. Corrosive materials can cause severe tissue damage and are particularly injurious to the eye. Storage of corrosive below eye level helps to minimize this risk.

12. Quantities of chemicals in storage should be consistent with the shortterm needs of the lab. Excessive storage should be avoided.

13. When transporting chemicals between rooms or buildings, secondary containers, such as bottle carriers, should be used. In the event the container is dropped, bumped or otherwise breaks, the contents would be contained in the bottle carrier, avoiding a spill. Bottle carriers are available in many stockrooms.

14. Some chemicals, such as ethers or other peroxide-formers, have recommended storage time limits. Chemicals stored beyond their limit date may form explosive peroxides, which may detonate when removing a cap, agitating, dropping, scraping, etc. Upon arrival, these containers should be marked with the date placed in storage and an expiration date based on manufacturer's recommendations. Many manufacturers include an expiration date on the product label.

15. To avoid difficult and potentially costly waste disposal problems, a procedure should be in place to assure all materials are labeled and unneeded chemicals disposed of properly.

List of gas cylinders and composition (add more rows if necessary)

Chemical Composition	**No of cylinders**
Total	

List of high-power lasers (add more rows if necessary)

Make	Wavelength	Pulsed or CW	Power of energy per pulse

Other observations/violations/comments:

10.2 No Food Label for Lab Refrigerators

NO FOOD OR DRINK

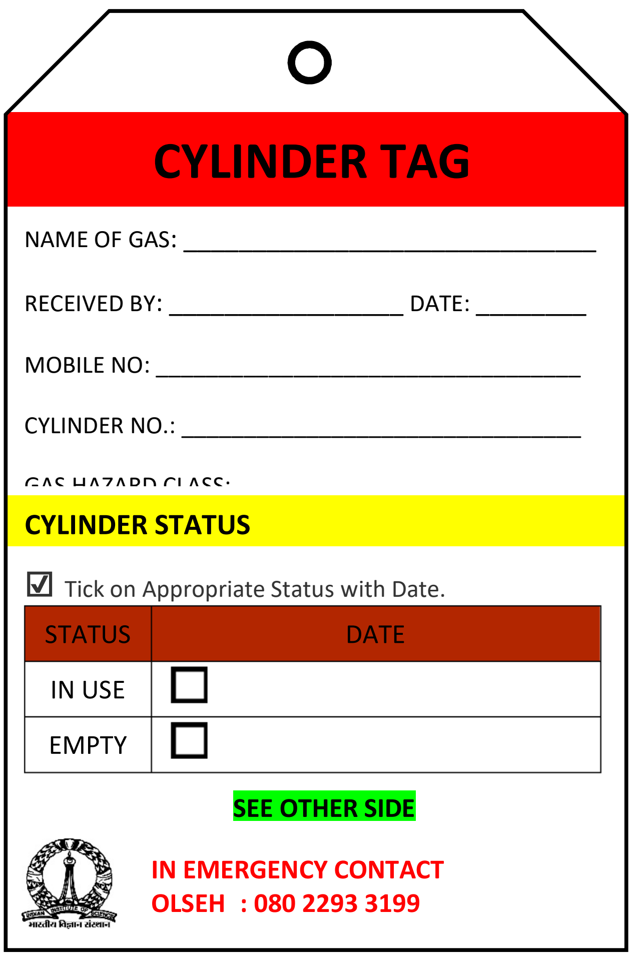
SHOULD BE STORED
IN THIS REFRIGERATOR

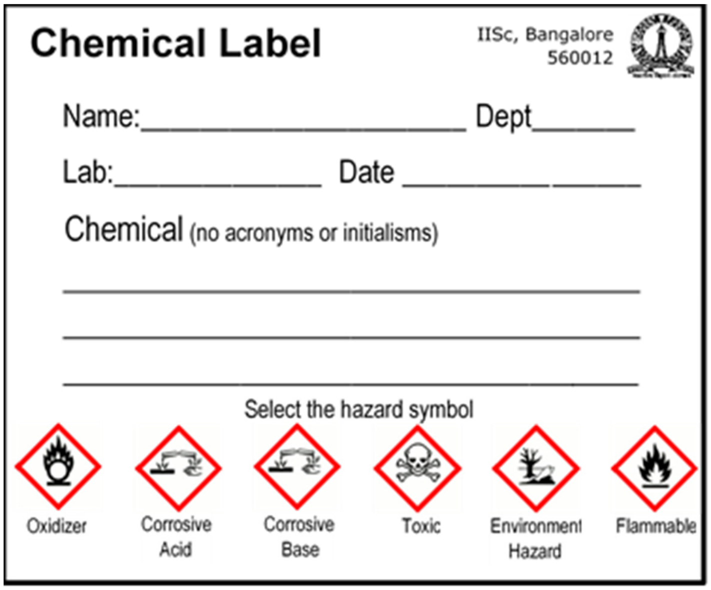
10.3 Gas Cylinder Labels

You can get these from CeNSE office.

10.4 Chemical Label

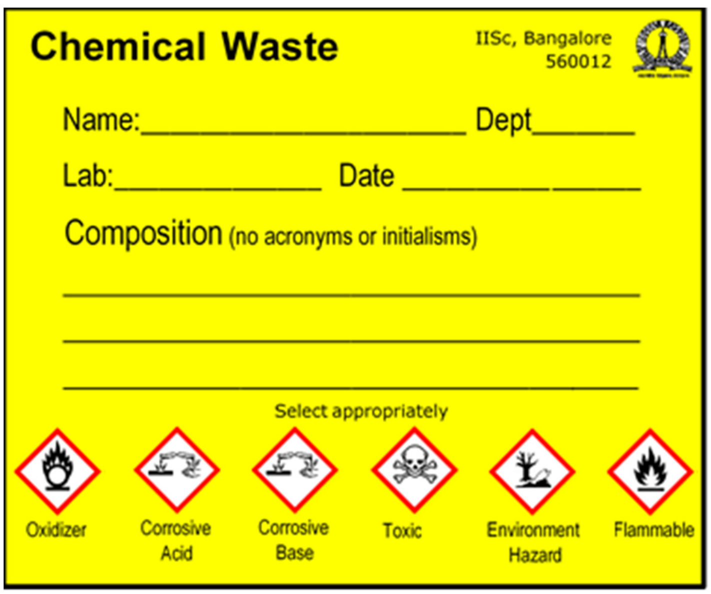
The individual departments are requested to print and stock them for use.




Chemical Label
IISc, Bangalore 560012
Name:____________________ Dept______
Lab:_____________ Date ______________
Chemical (no acronyms or initialisms)
____
____
____
Select the hazard symbol
Oxidizer | Corrosive Acid | Corrosive Base | Toxic | Environment Hazard | Flammable

10.5 Chemical Waste Label

The individual departments are requested to print and stock them for use.


Chemical Waste
IISc, Bangalore 560012
Name:____________________ Dept______
Lab:_____________ Date ______________
Composition (no acronyms or initialisms)
____
____
____
Select appropriately
Oxidizer | Corrosive Acid | Corrosive Base | Toxic | Environment Hazard | Flammable

10.6 Laboratory Hazard Sheet

1. Make a lab layout using some software and save it as an image file. Insert it in the 'Room floor plan' box.
2. Ensure that you include (in the floor plan)
    a. ALL windows and doors
    b. Location of wet benches, fume hoods, laser assembly, chemical storage, High-Voltage equipment, compressed cylinders and biological hazards
    c. Location of lab telephone and fire extinguishers and preferably light switches

3. Make use of the personal protective equipment table to specify protective gear like ‘Nitrile gloves’, ‘Laser safety glasses -xyz wavelength’ etc. Please be specific with the type of protective gear.
4. Use the ‘Description of Lab Hazards’ column to indicate hazardous substances. Reference symbols have been provided with this template document. Next to the symbol, specify the hazard as accurately as feasible. Eg: Laser- Class 4; Compressed cylinder-Silane; Acids - HF acid etc.
5. Prepare a new document once in 6 months or every time you make major changes such as shifting of equipment or addition of hazards in your lab.

Department: xyz

Room No: SF-XY

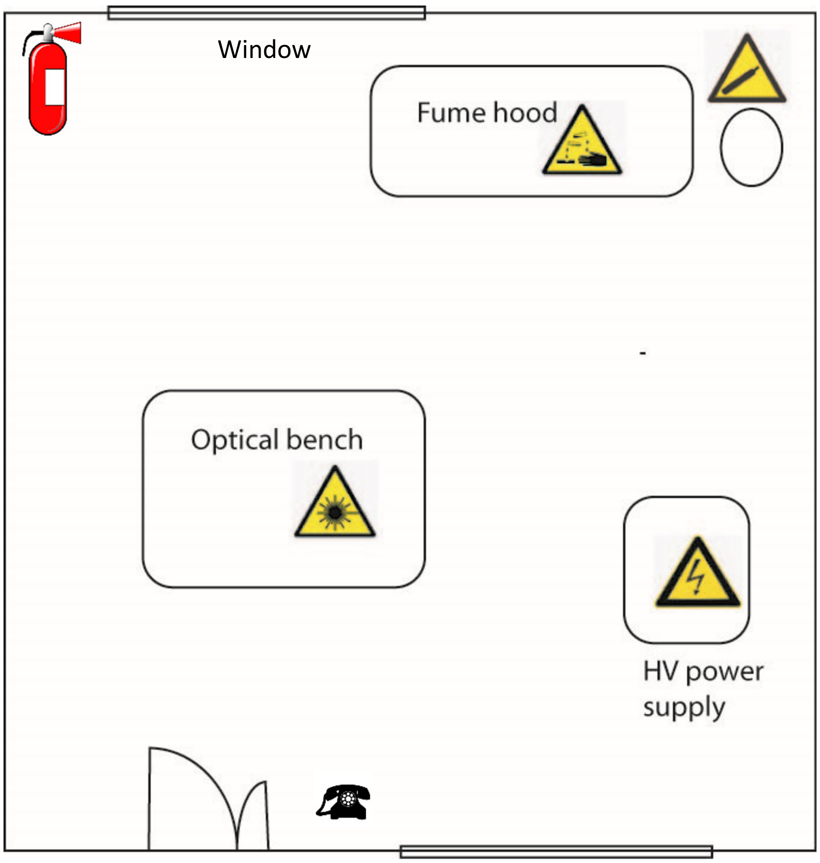
Lab Name: XYZ Lab

Review & Initials (every 6 months)

Date				
Initials				

Emergency Contact	Name	Office	Mobile
Safety In-charge 1	Student name 1	SF-XY	Mobile. No.
Safety In-charge 2	Student name 2	FF-XY	Mobile. No.
Faculty	Faculty Name	TF-XY	Mobile. No.

Room Floor Plan:



Description of Hazards	
	Nitrogen cylinder
	Acids in fume hood
	Class 3B He-Ne Laser
	HV power supply equipment

Reference symbols of hazards			
Compressed gas	Flammable	Toxic	Corrosive
Laser	High voltage	Radioactive	Bio-hazard

Protective equipment	
1	Laser safety glasses 632.8 nm
2	Nitrile gloves
3	Lab shoes
4	
5	