Indian Institute of Technology Mandi
Mandi-175001, Himachal Pradesh, India

भारतीय प्रौद्योगिकी संस्थान मण्डी
मण्डी -175075, हिमाचल प्रदेश, भारत

A Safety Manual for Laboratories/Academic & Research facilities

Indian Institute of Technology Mandi

Mandi-175075, Himachal Pradesh

Date: 30 August 2020

Prologue

Institute Safety committee is pleased to introduce the safety manual for the best and safe working practices at The IIT Mandi. This manual is drafted after studying and observing the best practices at various other institutes of the country and the world. The safety manual has been kept open for the future scrutiny and revision for improvement from time to time, which would be notified as and when required.

This manual will serve as the binding guidelines for safety practices in the institute. All the IIT Mandi community members (students/staffs/faculty) are requested to strictly adhere to the guideline and safe practices mentioned in this manual.

Institute safety committee is thankful to the IIT Mandi community for their suggestions and inputs in the formatting of this manual.

Thank you very much

Dr. C.S.Yadav	Dr. Sumit Sinha Ray	Dr. Parmod Kumar	Dr. Ankush Bag
(Chair)	(Member)	(Member)	(Member)

Dr. Rajanish Giri	Dr. Deepak Swami	Mr. Hardeep Singh
(Member)	(Member)	(Fire Officer)

Dr. P. Parmeswaran	Prof S.C. Jain
(Dean Academic)	(Dean Infra)

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1. INTRODUCTION

Safety is the first and foremost important aspect of an individual's life. The academic institution, involves various activities such as teaching, learning, investigating, exploring that require specific sets of training and guideline for safety. There is hardly any activity that are readily adaptable and hence the workers needs to understand and learn working protocol before beginning to work independently. It is very important to learn the guideline and safety practice before beginning the work. It is to always remember that **"Doing things safely is not merely the right way to do work; it is the only way to work."** This document compiles the essential safety practices specific to for working that needs to be followed. Besides the common safety hazards involving fire, electricity, and workspace, the laboratories are the places where researchers experiment their ideas with many tools, chemicals, gadgets etc. It is quintessential responsibility of the each individual to adhere to standard work practices in order to keep himself/herself and others safe. There are some general common set of rules that one should always keep in mind.

- Accidents don't just happen, they occur due to ignorance, faulty or improper handling of tools, wrong procedures and carelessness etc.
- Be emotionally prepared - under stress you are more prone to have an accident.
- Do not distract fellow workers during hazardous work or allow them to distract you.
- If you are prone for accidents, look for underlying physical and psychological reasons. "Accident proneness" is not an incurable disease.
- Remember Murphy's Law - If anything can go wrong, it will happen, sooner or later.
- Smoking is strictly prohibited in laboratory and campus premises.
- If you have an on job accident, notify your supervisor/safety officer in-charge.
- As new workers may be ignorant of hazards and safety procedures, all of them should get trained under an experienced person on how to do operate safely at workspace with appropriate protective equipments.
- If you find anyone adopting unsafe practices, raise your concern and alert him (irrespective of senior or junior person) about the same. Even after repeated alerting if the same person continues to adopt unsafe practices, please bring it to the notice of safety officer or laboratory in-charge.

2. FIRE SAFETY

2.1 INTRODUCTION AND NEED

- Fire is a hazard in any part of the premises. Its consequences include the threat to the lives or health and safety of relevant persons, scholars, students and damage to or loss of property and severe interruption to normal academic/administrative activities or opportunities.
- Managing the risk of fire demands fire safety precautions based on a combination of appropriate prevention and protection measures depending upon building use and occupancy, the inherent fire risks and the legal obligations.
- The fire safety management and fire emergency plan applies to all premises which are to any extent under the control of the **building/Lab owner**. Its requirements extend to all persons at those premises including staff, students and security personnel deployed.
- Where buildings/Labs are occupied or shares control of premises with the other Labs/sections then the arrangements for fire safety and maintenance will be coordinated, communicated and documented jointly.
- The fire safety management and fire emergency plan applies to all students/staff working in Labs/research facilities.

2.2 DEFINITION OF FIRE, FIRE TRIANGLE AND TETRAHEDRON

FIRE:

Fire is a chemical reaction where matter reacts with oxygen under certain conditions to release heat and light energy.

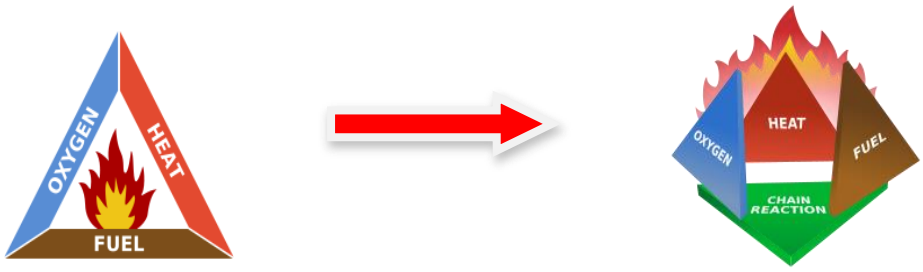

Fig 1.1: Fire triangle and its three elements.

FIRE TRIANGLE:

The triangle illustrates the three elements a fire needs to ignite: heat, fuel, and an oxidizing agent (usually oxygen).Three elements Fuel, Oxygen and Heat are necessary for initiation of a fire or combustion and is known as “Fire Triangle”. A fire can be prevented or extinguished by removing any one of the elements in the fire triangle.

FIRE TETRAHEDRON:

New understanding in ‘Fire Safety Management’ has necessitated the addition of a fourth

element to the Fire Triangle (i.e. the chemical chain reaction) making the fire triangle now a “Fire Tetrahedron”. The fire tetrahedron represents the addition of a component in the chemical chain reaction, to the three already present in the fire triangle. Once a fire has started, the resulting exothermic chain reaction sustains the fire and allows it to continue until or unless at least one of the elements of the fire is blocked. Foam can be used to deny the fire the oxygen it needs. Water can be used to lower the temperature of the fuel below the ignition point or to remove or disperse the fuel. Halon can be used to remove free radicals and create a barrier of inert gas in a direct attack on the chemical reaction responsible for the fire.

2.3 BASIC METHODS TO EXTINGUISH A FIRE

If the three parts of the ‘fire triangle’ are kept in mind, extinguishing a small blaze should be a matter of common sense. The principles of fire extinction state that a fire will be extinguished if one of the three element is removed, and this can be done using three different methods, as detailed below:

COOLING

Removing the heat is one of the most effective methods of fire extinction available, which is why water is a popular extinguishing material. The fire will go out so long as the heat generated by the fire is less than that which is absorbed by the water.

Remember: water is not an appropriate extinguishing material to use on electrical fires, as well as those caused by cooking oils/fats or other flammable liquids.

STARVING

While cooling removes the heat/ignition element of the ‘fire triangle’, starving the blaze of its fuel source approaches extinction from a different angle. A raging fire will burn itself out if it runs out of flammable materials, such as a bonfire out in the open that isn’t in contact with any other wood or dry grass. Similarly, a gas fire will immediately extinguish if the gas supply is cut off.

SMOTHERING

As the other key component present in the chemical reaction that causes combustion, removing oxygen from the fire triangle is the final way of extinguishing a fire. For example, smothering a frying pan blaze with a fire blanket reduces the oxygen to below the 16% required to react, while covering a candle with a glass will snuff it out in a vacuum.
Smothering is a technique that is mostly applicable to solid fuel fires, although some materials may contain enough oxygen within their own chemical makeup to keep the blaze burning.

INHIBITION

Inhibition means by quenching free radicals generated continuously by breaking/stopping the chain reaction of a sustained and continuous fire. Dry chemical powder or special agents can be used as inhibiting agent to stop the fire where applicable.

2.4 CLASSIFICATION OF FIRE AND THEIR PREVENTIONS

Various types of fire extinguishers specified in this standard are of value but all are not equally effective on all types of fire. For this reason, the nature of contents of a building, the processes carried out therein and the types of fire which may occur shall be taken into consideration while selecting fire extinguishers. For all practical purposes, the basic types of fires are classified into following five classes:

a. CLASS 'A' FIRE (GENERAL FIRE)

Fire involving solid combustible materials of organic nature such as wood, paper, clothes, rubber, plastics, etc. where the cooling effect of water is essential for extinction of fires.

b. CLASS 'B' FIRE (INFLAMMABLE LIQUIDS/GAS FIRE)

Fire involving flammable liquids or flammable gases, gasoline, paints, inflammable chemicals and liquefiable solids where a blanketing effect is essential.

c. CLASS 'C' FIRE (ELECTRICAL FIRE)

Fire involving live electrical equipment, loose wiring, short circuiting and overloading or excessive heating in the electrical appliances. The power supply should be disconnected immediately before attempting to extinguish the Electrical fires. It is important to note here that class 'C' fire will convert to class 'A' on disconnection of power supply from the source.

d. CLASS 'D' FIRE (METAL FIRE)

Fire involving combustible metals, such as magnesium, aluminium, zinc, sodium, potassium, etc, when the burning metals are reactive to water and water containing agents and in certain cases carbon dioxide, halogenated hydrocarbons and ordinary dry chemical powders. These fires require special agents and techniques to extinguish. When confronted with such a fire, common extinguishing agents such as water are ineffective and can be hazardous. To extinguish a Class D fire, use a dry powder agent. This absorbs the heat the fire requires to burn and smothers it as well.

e. CLASS 'K' FIRE

A Class K fire is defined as a cooking fire involving combustion from liquids used in food preparation. Technically a type of liquid fire, Class K fires is distinct enough to warrant their own classification. Cooking fires are fuelled by a wide range of liquid cooking materials. Cooking oils, vegetable fat, and animal fat are all fuel sources found in Class K fires. Class K fires are naturally of concern in the food service and restaurant industry. Such fires can be very dangerous and far more destructive than you may think. Wet chemical fire extinguishers have become popular in putting out these types of fires.

The classification of Fires, types of extinguishers used and Symbols on Extinguishers are tabulated below for ease of remembrance/recognition of correct fire extinguisher during actual fire related emergencies:

Class of Fire	Type of Fire	Type of Extinguisher	Extinguisher Identification	Symbol
A	Ordinary combustibles: wood, paper, rubber, fabrics, and many plastics	Water, Dry Powder, Halon		
B	Flammable Liquids and Gases: gasoline, oils, paint, lacquer, and tar	Carbon Dioxide, Dry Powder Halon		
C	Fires involving Live Electrical Equipment	Carbon Dioxide, Dry Powder Halon		
D	Combustible Metals or Combustible Metal Alloys	Special Agents		No Picture Symbol 
K	Fires in Cooking Appliances that involve Combustible Cooking Media: Vegetable or Animal Oils and Fats			

FIRE PREVENTIONS BASED ON THEIR CLASSIFICATION:

To Prevent class ‘A’ type of Fire, you should ensure/ do:

a. Good Housekeeping practices reduce the chances of General fire.
b. Keep storage living and working areas free of trash.
c. Place oily rags/combustible waste in the covered containers.
d. No Smoking is to be strictly adhered by all at Living/working areas.
e. Avoid accumulations of combustible waste and remove at least daily and store away from the building.

To Prevent class ‘B’ type of Fire, you should ensure/ do:

a. Store bulk stocks of highly flammable materials properly outside, in a separate building, or separated from the main workplace/Labs by fire-resisting construction.

b. Where there is a possibility of the presence of flammable gas/ vapour, conduct a full risk assessment and consider the need for gas detection equipment.
c. Provide clearly marked separate storage for flammable chemicals, gas cylinders, and waste materials.
d. The quantity of flammable liquids in workplace in the Labs should be kept to a minimum.
e. Container lids should always be replaced after use, and no container should ever be opened in such a way that it cannot be safely resealed.
f. Flammable liquids should be stored and handled in well ventilated conditions. Where necessary, additional properly designed exhaust ventilation should be provided to reduce the level of vapor concentration in the air.
g. Carefully read the Material Safety Data sheet of all chemicals before using them.

To prevent class 'C' type of Fire, you should ensure/ do:

a. Investigate any appliance or electrical equipment that smells strange. Unusual odors can be the first sign of a potential electrical fire.
b. Never install a fuse rated higher than specified for the circuit.
c. Utility lights should always have some type of wire guard over them.
d. Maintain proper pest control to avoid rodent damage to electric wiring and equipment.
e. Don't do loose wiring or take temporary connections in the Labs.
f. Use extension cords safety - not under carpets or across walking areas.
g. Please do not use power plugs more than their ratings.
h. Remember to switch off electrical appliances when not in use or while leaving workplace.

Fig 1.2: Fire in electrical appliances/equipment.

To Prevent class 'D' type of Fire, you should ensure or do:

a. Store inflammable metals away from the working areas.
b. Knowledge of the properties of the inflammable metals and using good judgment will assist you in controlling or avoiding potential fires/reactions.

To Prevent class 'K' type of Fire, you should ensure or do:

a. All Mess and canteens at IIT Mandi Campus are equipped with kitchens need to be well-equipped against the dangers of class K fires.
b. Appropriate extinguishers should be available near the cooking facility.

c. Mess workers should be trained to operate the fire extinguisher in case of fire.

d. Extreme care is to be taken while pouring vegetable oils or fats in a hot frying pan or container.

2.5 TYPES OF PORTABLE FIRE EXTINGUISHER

Generally three types of commonly used Portable fire extinguishers are:

(i) AFFF EXTINGUISHERS (Aqueous Film Forming Foam compound Water based Extinguishers)

Normally these Extinguishers are marked with alphabet **'A'** which denotes that these are suitable for **Class 'A'** or **General Fire**.

(ii) DRY CHEMICAL POWDEREXTINGUISHERS or **DCP** (MAP powder): Mono Ammonium Phosphate powder used in DCP Extinguishers.

Generally these Extinguishers are marked with alphabet **'A', 'B'**&**'C'** which denotes that these are suitable for **Class 'A, B, C'** types of **Fire** as explained above in Para 2.3 earlier.

(iii) CO_2 EXTINGUISHERS: CO_2 extinguisher contains liquefied carbon dioxide is suitable for **Class B** & **C** types of **Fire**. CO_2 extinguisher should be used on Electrical fires as the CO2 gas will disappear in the atmosphere from the equipment however DCP or Water based extinguisher may damage the equipment/appliance and needs extensive repairing/servicing.

Note: For class 'D' & 'K' fires, special agents/chemicals are used as applicable. The general appearance of above mentioned extinguishers are shown in the figure below:

Fig 1.3: Various classes/type of Fire extinguishers.

2.6 ANATOMY OF A BASIC FIRE EXTINGUISHER

Fig 1.4: Basic fire extinguishers and its components.

The Body of the **Extinguisher** is made of a special aluminum alloy which can endure the pressure. The other parts of the device, such as the nozzle, the valves, and the hose are made of less demanding materials, such as steel and plastics. The diagram above shows internal and external parts of a common fire extinguisher.

HOW TO USE/OPERATE PORTABLE FIRE EXTINGUISHERS

The acronym **"PASS"** is used to remember the four basic steps to operate any fire extinguisher in emergency:

1. **Pull**: The Pin at the top of the extinguisher, by breaking the seal.
2. **Aim**/ Approach the fire standing at a safe distance.
3. **Squeeze**: Squeeze the handles together to discharge the extinguishing agent on fire.
4. **Sweep**: Sweep the handle at the base of fire.

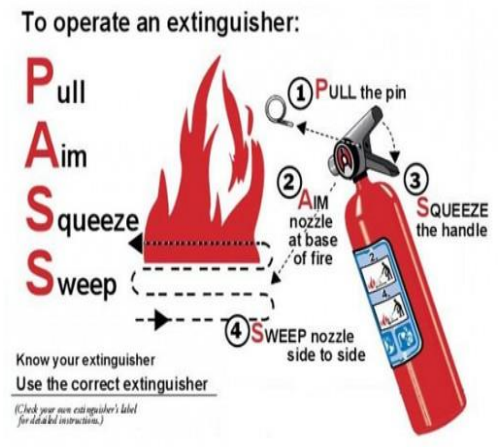

Fig 1.5: Operating guides (PASS) for fire extinguisher.

Very Important: Return the empty extinguisher immediately for refilling after use.

Note: (i) The extinguishing media is expelled from the extinguisher by carbon dioxide gas contained in a cartridge inside the extinguisher.

(ii) CO_2 extinguisher contains liquefied carbon dioxide. The gas present in the vapour space above the liquefied CO_2 itself acts as the propellant so no separate cartridge is used in CO_2 extinguisher.

2.7 FIRE FIGHTING DECISION CRITERIA

In case you notice Fire, your decision will depend on the following criteria to fight the fire, If:

- You can assess correctly whether the Fire is **small** and **contained**.
- You know the Labs emergency procedures and evacuation routes.
- You Know locations of fire extinguishers in your area and how to use them.
- Always sound the alarm regardless of fire size.
- Avoid smoky conditions.
- Ensure area is evacuated completely.
- Never use lifts to evacuate.
- Don't attempt to fight the fire unless, Alarm is sounded.
- You have safe egress route (can be reached without exposure to fire/smoke).
- Available extinguishers are rated for size and type of fire to be extinguished.
- Decide wisely, if in doubt, Evacuate immediately!
- "DON'T ATTEMPT TO FIGHT THE FIRE IF YOU ARE NOT TRAINED"

2.8 STANDARAD OPERATING PROCEDURE IN CASE OF FIRE

(A) What Students /Scholar/ Staff Should Do If They Discover a Fire

- Inform immediately on **01905-267096 (For South)** & **01905-267219 (For North Campus)** or **Institute Security Officer - 9418053088**
- Raise the alarm by operating the nearest fire alarm call point
- Try to use available appropriate portable Fire Extinguisher, if fire is small and you are well trained to operate the extinguishers.
- If you are unable to extinguish a small fire then **Evacuate** to a safe place with colleagues.
- **DO NOT USE THE LIFT**
- Trained fire safety personnel to tackle the fire only where appropriate.
- If have responsibilities for assisting persons with Personal Evacuation Plans respond as required following the actions as identified in the Plan.

- Leave the building by the nearest exit/**Emergency exit**.
- Do not stop or return to collect personal belongings.
- Ensure specially-abled personnel are escorted first from the building to the assembly point.
- Close any door en-route without delaying your escape.
- You must remain at the designated **Assembly point**.
- Return to the building only when authorised to do so.

(B) What Students /Scholar/ Staff should Do If They Hear the Fire Alarm

If you also have responsibilities for assisting persons with Personal Evacuation Plans respond as identified in the Plan. If not then:-

- Leave the building by the nearest exit/Emergency exit.
- Inform immediately on **01905-267096 (for South)** & **01905-267219 (for North**
- **Campus)** or **Institute Security Officer - 9418053088**
- Close any doors en-route without delaying your escape after ensuring 100% evacuation.
- Do not stop or return to collect personal belongings.
- Never use Lifts to evacuate from the buildings/Labs.
- Do not use any fire fighting equipment unless you have been trained.
- Do pass any crucial information to the building/Lab responsible person at the assembly point.
- You must remain at the assembly place.
- Return to the building only when authorised to do so.

2.9 EMERGENCY ESCAPE PLAN & ASSEMBLY POINT

Emergency Escape plan must be in place and practiced to ensure safe evacuation in the event of a fire or emergency. All workplaces/Labs must have clearly identified means of escape in the event of fire. These escape routes must be kept clear at all times to ensure that everyone can exit the workplace in the event of a fire or any other emergency. The general rule is that people should be able to turn their back on a fire, wherever it may start in a building, and move away from the fire to a safe place called **Assembly point**. Usually this means outside the building and a safe distance from it in case the fire grows.

Building In charges/Laboratory Coordinators are responsible for preparation of Emergency Escape Plan & Assembly point.

Following points must be considered before preparing Emergency Escape Plan & Assembly point of any building/Laboratory:

(i) Where the building increases in size and complexity, escape routes need to become more sophisticated and complex. Easier and wide corridors should be preferred in the escape route.

(ii) If there are Mobility-impaired people/disabled person works in the building/Labs then their needs must be taken into account while planning an evacuation strategy.

(iii) Florescent exit sign boards in the escape corridors/ routes should be installed for ease of exit by scholars/students/staff.

(iv) Regular mock drills should be conducted for evacuation.

(v) Sample Emergency Evacuation Plan of a building is available at ‘Appendix-A in this manual.

3. ELECTRICAL SAFETY

3.1 GENERAL

1. Electrical faults are frequent causes of accidents (both electric shock and fire).It is very important to **Avoid**

   (a) Temporary wiring
   (b) Railing leads
   (c) Overloaded lines
   (d) Wrong capacity fuses
   (e) Cables not properly anchored at terminals.
2. Follow proper color-coding of wires during changeover/ rewiring.
3. Single pole switches should be located in live line.
4. Use protective grommets in holes in instrument covers/ chassis.
5. In plug-socket extension cables, make sure that the socket is live.
6. Test prods should be properly designed and shrouded.

3.2 SAFETY GUIDELINES FOR ELECTRICAL LABS

The power levels and the rotating machines used in Electrical Labs can pose significant hazard to the laboratory users, if not handled properly. The major hazards associated with electricity are electrical shock and fire. Electrical shock occurs when the body becomes part of the electric circuit. In addition to the electrical shock hazards, sparks from electrical equipment can serve as an ignition source for flammable or explosive vapours. Some general guidelines that can be used to reduce the risk of injury caused by laboratory hazards are as follows:

1. Avoid contact with energized electrical circuits.
2. Disconnect the power source before servicing or repairing electrical equipment.
3. When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear nonconductive gloves and shoes with insulated soles.
4. If it is not unsafe to do so, work with only one hand, keeping the other hand at your side or in your pocket, away from all conductive material. This precaution reduces the likelihood of accidents that result in current passing through the chest cavity.
5. If water or a chemical is spilled onto equipment, shut off power at the main switch or circuit breaker and unplug the equipment.
6. If an individual comes in contact with a live electrical conductor, do not touch the equipment, cord or person. Disconnect the power source from the circuit breaker or pull out the plug using a leather belt.
7. Do not make circuit changes or perform any wiring when power is on.
8. Do not wear loose-fitting clothing or jewellery in the lab. Rings and necklaces are usual Excellent conductors in excellent contact with your skin.
9. It is wise in electrical labs to wear pants rather than shorts or skirts. Ties are also dangerous.

10. Powered equipment can be hot! Use caution when handling equipment after it has been operating.
11. Do your wiring, setup, and a careful circuit checkout before applying power.
12. Use wires of appropriate length. Do not allow them to drape over your equipment. Avoid splices, which create live surfaces. When running a pair of wires to adjacent terminals, twist the wires together so they don't dangle. This also neatens your work and will save time.
13. Do not touch anything if your hands are wet. The "one-hand" approach is safest.
14. If you can't keep your hand in your pocket, do not touch any metal object with free hand.
15. Do not pull wires out until you are absolutely sure that the circuit is completely dead. Shocks can occur if an inductive load (motor or transformer) is disconnected while conducting.
16. All the electrical equipment must be connected to the proper earth line.
17. All high voltage equipment must properly be marked and danger sign displayed.
18. Don't depend on switches to de-energize a circuit. Pull the plug out from the socket/outlet.
19. If you are working on high voltage circuits, have a co-worker along with you who knows how to break the circuit to get you free and how to give you mouth-to-mouth resuscitation and closed chest heart massage.
20. When you are mentally or physically tired, avoid work on energized circuits.
21. High voltage connections must have no sharp points.
22. Permanent or temporary enclosures around high voltage equipment should be used.

3.3 ELECTRIC SHOCK

Electric shock is one of the most common hazards encountered by people employed in installation, test, repair and operation of electrical or electronic equipment. Because they have survived shocks, they have a tendency to downgrade the danger. Unfortunately they forget that the same set of circumstances that kept the shock from being fatal once may combine differently on the next occasion to make the shock a KILLER.

It is true that "high voltage kills" but unfortunately some people have misconstrued it as if high voltage kills, low voltage cannot kill. Fatalities have occurred at ordinary household voltages of 110-120 V, 220-230 V and at as low voltages as 24 V AC. As such, no voltage can be considered as safe.

The severity of an electric shock depends on following factors:

a. The amount of current in mA that flows through your body.
b. Current pathway through body.
c. Duration of shock.
d. Frequency of current.
e. Phase of heart cycle.

The electrical resistance provided by the human body is made up of skin contact resistance and internal body resistance. The skin contact resistance varies with perspiration, skin puncture and conductor dampness. Dry uncut skin resistance can be as high as 250 Ω. A 600 V potential can quickly break down the skin resistance. The internal body resistance is about 500 Ω.
Table I provides some experimental extrapolated levels. Some of these levels are defined as:

Feeling threshold	**:**	the current that will produce slight sensation or tingling
"Let-go" threshold	**:**	current level where volunteers tested are just able to l et-go the conductor.
Freeze current	:	that level which is slightly in excess of "let-go" value, and which in AC voltage shock "freezes" the victim to the conductor.

Note: Summary of Quantitative Effects of Electric Currents on Humans is available at **Appendix-II** in this manual for information.

EFFECT OF ELECTRIC SHOCK

Perception Effect	-	at threshold level where a slight sensation or tingling is experienced.
Conscious phenomena	-	as current level increases pain and muscle soreness, ringing in ear, visual impairments such as flashes and spots before eyes occur.
Muscular contractions	-	AC causes muscular contractions. Current levels up to "let-go" value are painful, however at and above "freeze value" muscle contractions do not permit release of conductor.
Blood Pressure (BP)	-	A rapid increase in BP can occur due to muscle small contraction.
Stupor or collapse	-	Shocks at freeze value can render a person insensitive to surroundings or cause collapse.
Unconsciousness	-	Prolonged and/or strong shocks at freeze level can cause unconsciousness.
Paralysis of breathing	-	High voltages and/or currents passing through Mechanism breathing chest or vital nerve center scans cause paralysis of Nerve centres followed by asphyxiation and both.
Ventricular Fibrillation (VF)	-	At only moderate currents VF of heart can occur, a condition where the rhythmic pumping action of heart stops and blood circulation ceases. It is most hazardous, since heart fibrillation once started rarely reverts to normal rhythm naturally. A controlled counter shock is required, and the needed equipment is not usually readily available.

Burns	-	Two types of burns are of concern. First are those caused by electric current flowing through the body tissues, which are slow to heal. Second are thermal burns caused by elevated temperatures, such as, electric arcs, vaporized metals etc.
Haemorrhages	-	Depending on the magnitude of shock, the effect can vary from simple blood shot eyes to severe haemorrhages of the brain, nervous system and other organs.
Heart Standstill	-	High currents can cause standstill of the heart, and death in a few minutes if artificial resuscitation is not applied promptly.
Increase in body temperature	-	Very high currents can raise the body temperature and produce almost instant death.

3.5 STANDARD OPERATING PROCEDURE IN CASE OF ELECTRIC SHOCK

If you receive an electric shock: It might be difficult for you to do anything. But try to start with the following if you think you've been severely shocked:

(i) Let go of the electric source as soon as you can.

(ii) If you can, call **01905-267096 (For South)** & **01905-267219 (For North Campus)** or medical emergency services. If you can't, yell for someone else around you to call.

(iii) Don't move, unless you need to move away from the electric source.

(iv) See a doctor as soon as you can, even if you don't have any noticeable symptoms. Remember, some internal injuries are hard to detect at first.

(v) In the meantime, cover any burns with sterile gauze. Don't use adhesive bandages or anything else that might stick to the burn.

If someone else has been shocked: If someone else receives a shock, keep several things in mind to both help them and keep yourself safe:

(i) Don't touch someone who has been shocked if they're still in contact with the source of electricity.

(ii) Don't move someone who has been shocked, unless they're in danger of further shock.

(iii) Turn off the flow of electricity if possible immediately. If you can't, move the source of electricity away from the person using a non-conducting object, Wood and rubber are both good options. Just make sure you don't use anything that's wet or metal based.

(iii) Stay at least 20 feet away if they've been shocked by high-voltage power lines that are still on.

(vi) Call **01905-267096 (For South) & 01905-267219 (For North Campus)** or medical emergency services if the person was struck by lightning or if they came into contact with high-voltage electricity, such as power lines.

(vii) Call **01905-267096 (For South) & 01905-267219 (For North Campus)** or medical emergency services if the person has trouble breathing, loses consciousness, has seizures, has muscle pain or numbness, or is feeling symptoms of a heart issue, including a fast heartbeat.

(viii) Check the person's breathing and pulse. If necessary, start **CPR** until emergency help arrives.

(ix) If the person is showing signs of shock, such as vomiting or becoming faint or very pale, elevate their legs and feet slightly, unless this causes too much pain.

(x) Cover burns with sterile gauze if you can. Don't use Band-Aids or anything else that might stick to the burn.

(xi) Keep the person warm.

4. CHEMICAL SAFETY

4.1 CHEMICAL HANDLING WORK PRACTICES AND PROCEDURES

Carefully read the label before using a chemical. The manufacturer's or supplier's Material Safety Data Sheet may also provide special handling information. Be aware of potential hazards existing in the laboratory and the appropriate safety precautions. Know the location and proper use of emergency equipment, the procedures for responding to emergencies, and the proper methods for storage, transport and disposal of chemicals within the facility.

- Try not to work alone in the laboratory. If you must work alone or in the evening, let someone else know and have them periodically check on you.
- Label all secondary chemical containers with appropriate identification and hazard information.
- Use only those chemicals for which you have the appropriate exposure controls (such as a chemical fume hood) and administrative programs/procedures (training, restricted access, etc.). Always use adequate ventilation with chemicals. Operations using volatile or toxic substances should be performed in a chemical fume hood.
- Use hazardous chemicals and all laboratory equipment for their intended purpose only as directed.
- Inspect equipment or apparatus for damage before adding a hazardous chemical. Do not use damaged equipment.
- Inspect personal protective apparel and equipment for integrity or proper functioning before use.
- Malfunctioning laboratory equipment (such as a chemical fume hood) should be identified as "out of service" so that others will not inadvertently use it before repairs are made.
- Do not dispense more of a hazardous chemical than is needed for immediate use.

PERSONAL HYGIENE

- Remove contaminated clothing and gloves before leaving laboratory.
- Avoid direct contact with any chemical. Keep chemicals off your hands, face and clothing, including shoes. Never smell, inhale or taste a hazardous chemical. Wash thoroughly with soap and water after handling any chemical.
- Smoking, drinking, eating and the application of cosmetics is forbidden in laboratories where hazardous chemicals are used
- Never pipet by mouth. Use a pipet bulb or other mechanical pipet filling device.
- After working in a lab, wash your hands thoroughly with liquid soap.

HOUSEKEEPING

- Keep floors clean and dry. Keep all aisles, hallways, and stairs clear of all chemicals. Stairway and hallways should not be used as storage areas.
- Keep all work areas, and especially work benches, clear of clutter and obstructions.
- All working surfaces should be cleaned regularly.
- Access to emergency equipment, utility controls, showers, eyewashes and exits should never be blocked.
- Wastes should be kept in the appropriate containers and labeled properly.
- Any unlabeled containers are considered wastes at the end of each working day.

GLASSWARE SAFETY

Handle and store laboratory glassware with care. Do not use damaged glassware. Borosilicate glassware is recommended for all laboratory glassware except for special experiments that use UV or other light sources. Any glass equipment to be evacuated, such as suction flasks, should be specially designed with heavy walls. Glass equipment in pressure or vacuum service should be provided with shielding to protect users and other laboratory occupants. Glass vessels at reduced pressure are capable of collapsing violently, either spontaneously (if cracked or weakened) or from an accidental blow. Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them with safety netting to contain chemicals or fragments should implosion occur. Work with pressurized glass/plastic vessels or evacuated vessels requires use of the following PPE: face shield, safety goggles or glasses depending on the substance in the vessel, long-sleeved lab coat, and closed toe shoes.

HAZARDOUS CHEMICAL DEFINITION

A hazardous chemical is defined as any element, chemical compound, or mixture of elements and/or compounds which is a physical hazard or a health hazard. The standard applies to all hazardous chemicals regardless of the quantity.

A chemical is a physical hazard if there is scientifically valid evidence that it is a combustible liquid, a compressed gas, an explosive, an organic peroxide, an oxidizer or is pyrophoric, flammable, or reactive.

A chemical is a health hazard if there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles, that acute or chronic health effects may occur in exposed researcher/student. Classes of health hazards include:

- irritants
- carcinogens
- reproductive toxins

- corrosives
- sensitizers
- neurotoxins
- hepatotoxins
- nephrotoxins
- agents that act on the hematopoietic system
- asphyxiants
- agents that damage the lungs, skin, eyes, or mucus membranes

In most cases, the chemical container's original label will indicate if the chemical is hazardous. Look for key words like caution, hazardous, toxic, dangerous, corrosive, irritant, carcinogen, etc. Note that containers of hazardous chemicals acquired or manufactured before 1986 may not contain appropriate hazard warnings. (Please refer: ***http://www.iitmandi.ac.in/research/amrc/lab_safety.pdf***). If you are not sure a chemical you are using is hazardous, review the **Material Safety Data Sheet**.

HAZARD IDENTIFICATION

Some laboratories will synthesize or develop new chemical substances during the course of their research. If the composition of the substance is known and will be used exclusively in the laboratory, the researcher must label the substance and determine, to the best of his/her ability, the hazardous properties (e.g. corrosive, flammable, reactive, toxic, etc.) of the substance. This can sometimes be done by comparing the structure of the new substance with the structure of similar materials with known hazardous properties. If the chemical produced is of unknown composition, it must be assumed to be hazardous, and appropriate precautions should be taken.

4.2 TRAINING & INFORMATION

CHEMICAL SAFETY TRAINING

All researchers/students exposed, or potentially exposed, to hazardous chemicals while performing their laboratory duties must receive information and training regarding the standard and laboratory safety prior to working with these chemicals.
All researchers/students working in the laboratory must receive this training prior to beginning work with hazardous chemicals. When an researcher/student is to perform a non-routine task presenting hazards for which he or she has not already been trained, the student's/researcher's supervisor will be responsible for discussing with him/her the hazards of the task and any special measures (e.g. personal protective equipment or engineering controls) that should be used to protect the student/researcher.
Every researcher/student should know the location and proper use of available protective clothing and equipment, and emergency equipment/procedures.

Chemical Safety Information Sources:

There are the sources where you will find chemical safety information:

1. The labels found on containers of hazardous chemicals;
2. The substance's Material Safety Data Sheet (MSDS).

CONTAINER LABELING

All containers of hazardous chemicals which could pose a physical or health hazard to an exposed researcher/student must be labeled clearly identifying their contents. Labels on purchased hazardous chemicals must not be removed or defaced except when empty. If you use secondary working containers that will take more than one work shift to empty, or if there is a chance that someone else will handle the container before you finish it, you must label it. This is part of your responsibility to help protect co-workers. The label and information must be in English and clearly and fully identify the contents.

Many labels will provide you with additional safety information to help you protect yourself while working with this substance. This includes physical and health hazard warnings, protective measures to be used when handling the material, clothing that should be worn, first aid instructions, storage information and procedures to follow in the event of a fire, leak or spill. Read the label each time you use a newly purchased chemical. It is possible the manufacturer may have added new hazard information or reformulated the product since your last purchase, and thus altered the potential hazards you face while working with the product.

Fig 4.1: The basic parts of a chemical container labelling.

MATERIAL SAFETY DATA SHEETS

A Material Safety Data Sheet (MSDS) is a detailed informational document prepared by the manufacturer or importer of a hazardous chemical which describes the physical and chemical properties of the product. Information included in a Material Safety Data Sheet aids in the selection of safe products, helps researcher/student understand the potential health and physical hazards of the chemical, and describes how to respond effectively to exposure situations. It should be noted that the health and safety guidance in the Material Safety Data Sheet is often very generic and addresses worst case situations. It is not always helpful in selecting appropriate safeguards in the laboratory. Material Safety Data Sheets for most chemicals are readily available on-line.

The format of a Material Safety Data Sheet may vary but there is specific information that must be included in each sheet. All MSDSs must contain the following information:

- Identity of the product, using the name used on the original label
- The chemical and common names of the hazardous ingredients, if in concentration >1% (>0.1%for carcinogens)
- Physical and chemical characteristics of the product
- Physical and health hazards of the product, specifying carcinogens at >0.1% concentration
- Primary routes of entry
- Exposure limits, if any
- Safe handling and use information
- Engineering and personal protective equipment control recommendations
- Emergency and first aid procedures
- Date of the MSDS revision
- Name and contact information of the chemical manufacturer, importer, or other responsible party preparing or distributing the MSDS.

SIGNS

Prominent signs of the following types should be posted in each laboratory:

- Door ID cards outside each laboratory listing the names and telephone numbers of the Principal investigator and other responsible laboratory personnel. These cards must be kept updated and are used by emergency responders in the event of an off-hours emergency in the laboratory.
- Emergency contact numbers prominently located on or near the laboratory phone.
- Radiation safety or biological safety signs at laboratory doors, sinks, benches, hoods, etc, as appropriate.
- Signs identifying locations for safety showers, eyewash stations, other safety and first aid equipment, and exits.
- Warnings at areas or equipment where special or unusual hazards exist.

4.3 WHEN NOT TO PROCEED WITHOUT REVIEWING SAFETY PROCEDURES

Sometimes laboratory workers should not proceed with what seems to be a familiar task. Hazards may exist that are not fully recognized. Certain indicators should cause the researcher/student to stop and review the safety aspects of their procedure. These indicators include:

- New procedure, process or test even if it is very similar to older practices.
- A change or substitution of any of the ingredient chemicals in a procedure.
- A substantial change in the amount of chemicals used (scale up of experimental procedures); usually one should review safety practices if the volume of chemicals used increases by 200%.
- A failure of any of the equipment used in the process, especially safeguards such as chemical fume hoods.
- Unexpected experimental results (such as a pressure increase, increased reaction rates, unanticipated byproducts). When an experimental result is different from the predicted, a review of how the new result may affect safety practices should be made.
- Chemical odors, illness in the laboratory staff that may be related to chemical exposures, or other indicators of a failure in engineered safeguards.

The occurrence of any of these conditions should cause the researcher to pause, evaluate the safety implications of these changes or results, make changes as necessary and proceed cautiously.

4.4 PROTECTIVE CLOTHING AND LABORATORY SAFETY EQUIPMENT

Personal protective clothing and equipment should be selected carefully and used after all feasible engineering and administrative controls have been put in place or while such controls are being established. These devices are viewed as less protective than other controls because they rely heavily on each researcher/student's work practices and training to be effective. The engineering and administrative controls that should always be considered first when reducing or eliminating exposures to hazardous chemicals include:

- Substitution of a less hazardous substance or less hazardous equipment or process
- Scaling down size of experiment
- Isolation of the operator or the process
- Local and general ventilation (e.g., use of fume hoods)

A laboratory coat, gloves, protective eyewear, and closed toe shoes are required to be worn in laboratories whenever handling hazardous chemicals. Additional personal protective equipment, such as face shield, utility gloves, aprons, and respirators, may be necessary depending on an assessment of the hazard and operation.

- PROTECTION OF SKIN AND BODY

  Skin and body protection involve wearing protective clothing over all parts of the body that could potentially become contaminated with hazardous chemicals. Personal

protective equipment (PPE) should be selected on a task basis, and checked to ensure it is in good condition prior to use (e.g. no pinholes in gloves).

- STANDARD LABORATORY CLOTHING

Where there is no immediate danger to the skin from contact with a hazardous chemical it is still prudent to select clothing to minimize exposed skin surfaces in the laboratory. Researcher/students shall not wear shorts, short skirts or sandals in a laboratory. A laboratory coat with cuffs at the sleeves should be worn over street clothes and be laundered regularly. Laboratory coats are intended to prevent contact with dirt, chemical dusts and minor chemical splashes or spills. If it becomes contaminated it should be removed immediately and the affected skin surface washed thoroughly. Closed-toe shoes should be worn in the laboratory at all times.

- PROTECTIVE CLOTHING

Additional protective clothing may be required for some types of procedures or with specific substances or operations; such as when carcinogens or large quantities of corrosives, oxidizing agents or organic solvents are handled. This clothing may include chemically resistant aprons and gloves as well as face shields, shoe covers, and arm sleeves. These should never be worn outside the laboratory. The choice of garment depends on the degree of protection required and the areas of the body that may become contaminated. Rubberized aprons, plastic coated coveralls, shoe covers, and arm sleeves offer much greater resistance to permeation by chemicals than laboratory coats and, therefore, provide additional time to react (remove the garment and wash affected area) if contaminated.

If you are working with substances of high acute or chronic toxicity and wearing washable garments (such as a laboratory coat), evaluate the potential for exposing non-laboratory personnel when laundering. Wear disposable garments if others may be placed at risk during the laundering process.

For work where contamination with highly hazardous chemicals is possible, special attention must be given to sealing all openings in the clothing. Tape can be utilized for this purpose. In these instances caps should also be worn to protect hair and scalp from contamination.

- GLOVES

Chemical resistant gloves should be worn whenever handling hazardous chemicals or whenever there is a possibility of contact with hazardous materials. Gloves should be selected on the basis of the materials being handled, the particular hazard involved, and their suitability for the operation being conducted. Before each use, gloves should be checked for integrity. Thin exam-style gloves are most commonly used for laboratory work, and are disposed of in the regular trash after each use. In general, nitrile exam-style gloves offer better chemical protection than either latex or vinyl and all laboratories that use chemicals are strongly encouraged to stock and use nitrile gloves. Latex gloves are discouraged not only because they do not hold up well to many chemicals, but also

because of the potential for the user or other lab personnel to develop a sensitization to the latex. Nitrile exam style gloves are generally more chemically resistant than vinyl or latex, but due to the thinness of these gloves thicker utility style reusable gloves should be worn if there is a probability of contact with hazardous chemicals. These gloves should be washed prior to removal and replaced periodically, depending on frequency of use and their resistance to the substances handled. The following table offers a general guide to glove selection.

Glove Material	**Intended Use**	**Advantages**	**Disadvantages**
Latex exam style	Incidental Contact	Good for biological and water-based materials, User acceptability	Poor for organic solvents, Hard to detect puncture holes, Latex allergy issues
Nitrile exam style	Incidental Contact	Good for solvents, oils, greases, some acids and bases, Clear indication of tear and breaks,User acceptability	Slightly more expensive than latex
Utility style Nitrile– Solvex	Extended Contact	Good for solvents, oils, greases, some acids and bases, Can be washed and reused	Not effective for halogenated and aromatic hydrocarbons
Neoprene – utilityStyle	Extended contact	Good for acids, bases, alcohols, fuels, peroxides, hydrocarbons, and phenols	Not effective for halogenated and aromatic hydrocarbons
Butyl rubber Utility gloves	Extended contact	Good for ketones and esters	

- EYE PROTECTION

Eye protection is required for all personnel, students, and any visitors present in locations where chemicals are handled and a chemical splash hazard exists. Safety glasses, goggles and goggles with face shield should be worn in the laboratory based upon the physical state, the operation or the level of toxicity of the chemical used. Safety glasses with side shields effectively protect the eye from solid materials (dusts and flying objects) but are less effective at protecting the eyes from chemical splash to the face. Safety glasses are the minimum eye protection that must be worn in the laboratory. Goggles should be worn in situations where bulk quantities of chemicals are handled and chemical splashes to the eyes are possible. Goggles form a liquid proof seal around the eyes, protecting them from a splash. When handling highly reactive substances, chemicals under pressure, or larger quantities of corrosives, poisons, and hot chemicals, goggles with face shield should be worn.

- PROTECTION OF THE RESPIRATORY SYSTEM

Inhalation hazards can be controlled using ventilation or respiratory protection. Check the label and MSDS for information on a substance's inhalation hazard and special ventilation requirements. When a potential inhalation hazard exists a substance's label or MSDS contains warnings such as:

- Avoid inhalation of vapors
- Use with adequate ventilation
- Use in a fume hood
- Provide local ventilation

Take appropriate precautions before using these substances. Controlling inhalation exposures via engineering controls (ventilation) is always the preferred method. As with other personal protective equipment, respiratory protection relies heavily on researcher/student work practices and training to be effective.

4.5 CHEMICAL SAFETY EQUIPMENT

A. CHEMICAL FUME HOODS

In the laboratory the chemical fume hood is the primary means of controlling inhalation exposures. Hoods are designed to retain vapors and gases released within them, protecting the laboratory worker's breathing zone from the contaminant. Chemical fume hoods can also be used to isolate apparatus or chemicals that may present physical hazards to researcher/students. The closed sash on a hood serves as an effective barrier to fires, flying objects, chemical splashes or spattering and small implosions and explosions. The saches of hoods should be kept as low as possible when not actively working in the hood. When using a chemical fume hood keep the following principles of safe operation in mind:

- Keep all chemicals and apparatus at least six inches inside the hood behind the sash.
- Hoods are not intended for storage of chemicals and materials stored in them should be kept to a minimum. Stored chemicals should not block vents or alter airflow patterns.
- Follow the instructions on the "Safe Use of Laboratory Fume Hoods" sticker posted on all hoods. For constant volume hoods, set the appropriate sash opening by lining up the red arrows placed on the sash door and hood frame. This sash opening will ensure the appropriate air velocity through the face of the hood. For variable air volume hoods, keep the hood sash lowered when not manipulating chemicals or adjusting apparatus within the hood. (please refer: ***http://www.iitmandi.ac.in/research/amrc/lab_safety.pdf***)
- Follow the chemical manufacturers or supplier's specific instructions for controlling inhalation exposures with ventilation when using their products. These instructions are located on the MSDS and/or label. It is recommended that all work involving volatile or

higher hazard chemicals be conducted inside a chemical fume hood whenever feasible.

B. EYEWASHES AND SAFETY SHOWERS

Whenever chemicals have the possibility of damaging the skin or eyes, an emergency supply of water must be available. All laboratories in which hazardous chemicals are handled and could contact the eyes or skin resulting in injury should have ready access to plumbed eyewash stations and safety showers. To ensure easy access and safe use of eyewashes and safety showers:

- Keep all passageways to eyewashes and safety showers clear of any obstacle. This includes even temporary storage of supplies, carts, etc.
- Ensure that you and all laboratory personnel know the location of the nearest eyewashes and safety showers, and how to operate them.
- Eyewashes should be checked routinely by laboratory personnel to be certain that water flows through it. Allow them to run for several minutes once per week to clear out the supply lines.
- Showers should be checked routinely by laboratory personnel to assure that access is not restricted and that the start chain or lever is within reach.

4.6 CHEMICAL PROCUREMENT, DISTRIBUTION, AND STORAGE

A. PROCUREMENT

Before a new substance that is known or suspected to be hazardous is received, those individuals who will handle it should have information on proper handling, storage, and disposal. It is the responsibility of the principal investigator or the supervisor to ensure that the laboratory facilities in which the substance will be handled are adequate and that those who will handle the substance have received the proper information and training. The necessary information on proper handling of hazardous substances can be obtained from the Material Safety Data Sheets which are provided by the vendor. Order the smallest amount of chemical needed as possible.

B. DISTRIBUTION

All containers of hazardous chemicals should be transported in a secondary container such as a chemical carrier. These carriers are commercially available and provide both secondary containment as well as "bump" protection. If several bottles must be moved at once, the bottles should be transported on a small cart with a substantial rim to prevent slippage from the cart. Wherever available, a freight elevator should be used to transport chemicals from one floor to another.

C. CHEMICAL STORAGE IN THE LABORATORY

Carefully read the label before storing a hazardous chemical. The MSDS will provide any special storage information as well as information on incompatibilities. Do not store unsegregated liquid chemicals in alphabetical order. Do not store incompatible chemicals in close proximity to each other. Separate hazardous chemicals in storage as follows:

Solids: - oxidizers
- flammable solids (phosphorus, magnesium, lithium)
- water reactives

Liquids: - flammable/combustible
- inorganic acids
- organic acids
- caustics
- oxidizers

Gases: - toxic
- oxidizers
- flammable

Once separated into the above hazard classes, chemicals may be stored alphabetically.

- Use approved storage containers and safety cans for flammable liquids. It is preferable to store flammable chemicals in flammable storage cabinets. No greater than 10 gallons of flammable liquids may be kept outside of rated flammable storage cabinets in any laboratory. Flammable chemicals requiring refrigeration should be stored only in the refrigerators and freezers specifically designed for flammable storage.
- Hazardous chemicals should not be stored on bench tops, on the floor, or in hoods. Chemicals should also not be stored under sinks, if possible. If separate cabinets are not feasible, chemicals of different chemical classes can be segregated by placing them in trays. Corrosive or hazardous liquids should not be stored above eye level.
- Use secondary containers for highly corrosive or toxic chemicals.
- Avoid exposure of chemicals while in storage to heat sources (especially open flames) and direct sunlight.
- Conduct periodic inventories of chemicals stored in the laboratory and dispose of old or unwanted chemicals promptly.
- Assure all containers are properly labeled with the identity of the contents and any appropriate hazard warnings.

D. CHEMICAL STORAGE - CHEMICAL STABILITY

Stability refers to the susceptibility of a chemical to dangerous decomposition. The label and MSDS will indicate if a chemical is unstable.

Special note: peroxide formers - Ethers, liquid paraffins, and olefins form peroxides on exposure to air and light. Peroxides are extremely sensitive to shock, sparks, or other forms of accidental ignition and can be even more sensitive than primary explosives such as TNT. Since many of these chemicals are packaged in an air atmosphere, peroxides can form even though the containers have not been opened. All containers of ether or other peroxide formers should be dated upon receipt and discarded by the expiration date on the container. If the container does not have an expiration date but the chemical is a

peroxide-former, the container should be discarded after one (1) year of receipt, even if unopened. Highly Reactive Chemicals and High Energy Oxidizers for additional information on storage limitations and examples of materials which may form explosive peroxides. (Check ***Appendix Table 1***)

CHEMICAL STORAGE - INCOMPATIBLE CHEMICALS

Certain hazardous chemicals should not be mixed or stored with other chemicals because a severe reaction can take place or an extremely toxic reaction product can result. The label and MSDS will contain information on incompatibilities and should always be consulted. Table 2 in Appendix contains examples of incompatible chemicals, but is not a complete list.

4.7 CHEMICAL SPILLS & ACCIDENTS

Try to anticipate the types of chemical spills that can occur in your laboratory and obtain the necessary equipment (spill kits and personal protective equipment) to respond to a minor spill. Learn how to safely clean up minor spills of the chemicals you use regularly. An MSDS contains special spill clean-up information and should also be consulted. Chemical spills should only be cleaned up by trained, knowledgeable and experienced personnel.
The following compounds are very hazardous. You should not clean them up yourself:

- Aromatic amines
- Hydrazine
- Bromine
- Organic Halides
- Carbon disulfide
- Nitriles
- Cyanides
- Nitro compounds
- Ethers and other 1A flammable solvent

CLEANING UP CHEMICAL SPILLS

If you are cleaning up a small spill yourself, make sure that you are aware of the hazards associated with the materials spilled, have adequate ventilation (open windows, chemical fume hood on) and proper personal protective equipment (minimum - gloves, goggles, and lab coat). Consider all residual chemical and cleanup materials (adsorbent, gloves, etc.) as hazardous waste. Place these materials in sealed containers (plastic bags), label, and store in a chemical fume hood

Minor Chemical Spill

- Alert people in immediate area of spill.
- Increase ventilation in area of spill (open windows, turn on hoods).
- Wear protective equipment, including safety goggles, gloves, long-sleeve lab coat and closed toe shoes.
- Avoid breathing vapors from spill.
- Use appropriate kit to neutralize and absorb inorganic acids and bases. Collect residue, place in container, and dispose as hazardous chemical waste.
- For other chemicals, use appropriate kit or absorb spill with vermiculite, dry sand, diatomaceous earth, spill pads, or paper towels. Collect residue, place in container, and dispose as chemical waste.
- Clean spill area with water.

Major Chemical Spill

- Attend to injured or contaminated persons and remove them from exposure.
- Alert people in the laboratory to evacuate.
- If spilled material is flammable, turn off ignition and heat sources. Place spill cleanup material over spill to keep substance from volatilizing.
- Close doors to affected area.
- Have a person with knowledge of the incident and laboratory available to answer questions from responding emergency personnel.
- Mercury Spills
- Do not use a domestic or commercial vacuum cleaner.
- Use a disposable pipette to pick up mercury droplets.

Alkali Metal Spills

- Smother with powdered graphite, sodium or calcium carbonate.
- White Phosphorous
- Smother with wet sand or wet "noncombustible" absorbent.

4.8 PERSONAL CONTAMINATION AND INJURY

- Know the locations of the nearest safety shower and eye wash fountain.
- Report all incidents and injuries to your supervisor.
- If an individual is contaminated or exposed to a hazardous material in your laboratory do what is necessary to protect their life and health as well as your own. Determine what the individual was exposed to. The MSDS may contain special first aid information.
- Do not move an injured person unless they are in further danger (from inhalation or skin exposure).
- A blanket should be used immediately to protect the victim from shock and exposure.

CHEMICALS SPILLS ON THE BODY

- Quickly remove all contaminated clothing and footwear.
- Get to a safety shower and immediately flood the affected body area for at least 15 minutes. Remove jewelry to facilitate removal of any residual material.

It should be noted that some chemicals (eg. phenol, aniline) are rapidly adsorbed through the skin. If a large enough area of skin is contaminated an adverse health effect (systemic toxicological reaction) may occur immediately to several hours after initial exposure depending on the chemical. In general, if more than 9 square inches of skin area has been exposed to a hazardous chemical, seek medical attention after washing the material off the skin.

CHEMICALS SPILLS ON THE BODY – HYDROFLUORIC ACID (HF)

Calcium gluconate gel is an effective treatment for hydrofluoric acid exposure. Every laboratory and location where HF is used or stored should have a tube of calcium gluconate readily available.

In the event of an HF spill to the body:

- Immediately flood the affected body area with cool water for a minimum of 5 minutes, if calcium gluconate is available. If no calcium gluconate is immediately available, continue rinsing the affected area until emergency medical responders arrive, using copious amounts of water. Remove contaminated clothing and footwear while rinsing.
- Gently rub calcium gluconate ointment onto the affected area. Continue applying until emergency medical responders arrive.
- Inform responders and all others that the exposure involved hydrogen fluoride/hydrofluoric acid.

CHEMICAL SPLASH IN THE EYE

- Use eyewash to irrigate the eyeball and inner surface of eyelid with plenty of water for at least 15 minutes. Forcibly hold eyelids open to ensure effective wash.
- Check for and remove contact lenses.
- Get medical attention promptly.

IDENTIFY INGESTION OF HAZARDOUS CHEMICALS

- Identify the chemical ingested.
- Cover the injured person to prevent shock.
- Provide the ambulance crew and physician with the chemical name and any other relevant information. If possible, send the container, MSDS or the label with the victim.

INHALATION OF SMOKE, VAPORS AND FUMES

- Anyone overcome with smoke or chemical vapors or fumes should be removed to uncontaminated air and treated for shock.
- Do not enter the area if you expect that a life threatening condition still exists -oxygen depletion,explosive vapors or highly toxic gases (cyanide gas, hydrogen sulfide, nitrogen oxides, carbonmonoxide)
- If CPR (Cardiopulmonary resusciation) certified, follow standard CPR protocols.
- Get medical attention promptly.

4.9 CHEMICAL WASTE DISPOSAL MANAGEMENT

Laboratory chemical waste must be handled according to Institute's policy and guidelines. Waste management practices should be designed to ensure maintenance of a safe and healthful environment for laboratory researcher/students and surrounding community without adversely affecting the environment. Wastes such as solid waste, aqueous waste, solvents (chlorinated and non-chlorinated), broken glassware, plastic waste, sharp objects should be properly disposed of with the help of some external agency.

5. MACHINE AND EQUIPMENT SAFETY

5.1 INTRODUCTION

Unguarded moving parts of machines/equipment and the sudden or uncontrolled release of their power systems can result in serious injuries. Personnel working with machines must be aware of the risks involved and follow safe work practices. Some of the common causes of accidents while working with the machinery are as follows:

- Loose clothing, hair, jewellery being caught in moving parts.
- Materials ejected from the machine when it is operational.
- Inadvertent starting of the machine.
- Slipping and falling into an unguarded nip.
- Contact with sharp edges, e.g., cutting blade.
- Making adjustments while the machine is operational.
- Unauthorized operation of machines.
- Lack of preventive maintenance.

Here, we provide guidelines for machinery and equipment safety in order to assist persons working with machines to comply with their duties under the Work Health and Safety Act 2011 and the Work Health and Safety Regulation 2011. This guide is an introduction to managing the risks associated with use of machinery and equipment in the workplace. It can be used to identify machinery and equipment hazards in the workplace and to eliminate or reduce the risk of those hazards causing harm.

5.2 CATEGORIZATION OF HAZARDS

A. MECHANICAL HAZARDS

Machinery and equipment have moving parts. The action of moving parts may have sufficient force in motion to cause injury to people. When assessing machinery and equipment for possible mechanical hazards (Fig. 1.1), consider:

- machinery and equipment with moving parts that can be reached by people,
- machinery and equipment that can eject objects (parts, components, products or waste items) that may strike a person with sufficient force to cause harm,
- machinery and equipment with moving parts that can reach people, such as booms or mechanical appendages (arms),
- mobile machinery and equipment, such as forklifts, pallet jacks, earthmoving equipment, operated in areas where people may gain access.

Fig. 5.1: Various sources of mechanical hazards associated with machine tools.

Common mechanical hazards and associated risks for machinery and equipment are shown below.

Hazard	**Risk**
Rotating shafts, pullies, Couplings, sprockets and gears	Entanglement
Hard surfaces moving together	Crushing
Scissor or shear action	Severing
Sharp edge–moving or stationary	Cutting or puncturing
Cable or hose connections	Slips, trips and falls (e.g. oil leaks)

B. NON-MECHANICAL HAZARDS

Non-mechanical hazards associated with machinery and equipment can include harmful emissions, contained fluids under pressure, chemicals and by-products, electricity and noise, etc. All of these can cause serious injury if not controlled adequately. In some cases, people exposed to these hazards may not show signs of injury or illness for years. Where people are at risk of injury due to harmful emissions from machinery and equipment, the emissions

should be controlled at their source. When assessing machinery and equipment for possible non-mechanical hazards, consider how machinery and equipment can affect the area (environment) around them.

C. ACCESS HAZARDS

People must be provided with safe access that is suitable for the work they perform in, on and around machinery and equipment. A stable work platform, suited to the nature of the work that allows for good posture relative to the work performed, sure footing, safe environment and fall prevention, is a basic requirement. When thinking about safe access to machinery and equipment, consider the following:

- who will be working on or around the machinery and equipment,
- people who are required to work in enclosed areas where the atmosphere could be harmful, such as pits, tanks or storage vessels,
- what equipment or materials need to be carried to undertake the task,
- where and when is access required for operation, maintenance and cleaning,
- how will people gain safe access (walkway, gantry, elevated work platform or ladder),
- what work will be carried out during access,
- will people be near or exposed to an unidentified mechanical or non-mechanical hazard at the time of access,
- has consultation occurred with workers regarding how they intend to gain access, and what equipment and work platform or structure is best suited for the intended task?

5.3 RISK CONTROL OF MACHINERY AND EQUIPMENT HAZARDS

A. RISK CONTROL OF GENERAL HAZARDS

Where exposure to machinery and equipment hazards cannot be eliminated or substituted for machinery and equipment of improved design, risk controls must be applied to the hazards to prevent or reduce the risk of injury or any other harm. Workplace health and safety laws require the highest order control be applied. Higher order machinery and equipment risk controls are preventative by nature, are effective and durable for the environment it is used in and deal directly with the hazard at its source. Lower order machinery and equipment risk controls, such as personal protective equipment (PPE), can prevent injuries, but are generally not as effective as higher order controls, as they rely more on worker behaviour, maintenance programs and supervision.

Administrative controls use systems of work to reduce risk by providing a framework of expected behaviours. Examples are rotation of staff to reduce exposure to a hazard, or a documented safe system of work, such as ‘lockout tagout’. These types of controls rely on

extensive instruction, information, training and supervision. In terms of time and ongoing administration by managers and employers to ensure the desired behaviour occurs, administrative controls can be the most expensive and least effective form of hazard control.

Effective machinery and equipment risk controls reflect some or all of the following characteristics:

- the hazard is controlled at its source,
- contact or access to the hazard is prevented,
- sturdy construction (correct materials with few points of potential failure),
- fail-safe (failure of the control system to be effective will result in machinery shut down),
- tamper-proof design (as difficult as possible to bypass),
- presents minimum impediment to machinery and equipment operator,
- easy to inspect and maintain,
- does not introduce further hazards through the risk control action.

B. RISK CONTROL OF MECHANICAL HAZARDS

Separation is a simple and effective machinery and equipment risk control and may be achieved by distance, barrier or time. Distance separation means a person cannot reach the hazard due to distance. Barrier separation means an effective barrier or guard denies access and controls ejection of parts, products or waste. Time separation means at the time of access, the machinery and/or equipment is disabled. For example fences, screens, guarding and interlocking, etc.

Any machine part which can cause injury, must be guarded. Machine guards help to eliminate personnel hazards created by points of operation, ingoing nip points, rotating parts and flying chips.

Commonly used machine guards are as follows:

Fixed guard: is kept in place permanently by fasteners that can only be released by the use of a tool.

Interlocked guard: shuts off or disengages power to the machine and prevents it from starting when the guard is removed/opened.

Adjustable guard: provides a barrier which can be adjusted to suit the varying sizes of the input stock.

Self-adjusting guard: provides a barrier which moves according to the size of the stock entering the danger area.

Pull back guard: the device is attached to the wrist of the operator which pulls the operator's hands away from the point of operation or other hazardous areas when the machine operates.

Two hand control: concurrent use of both hands is required to operate the machine, preventing the operator from reaching the danger area.

Fig 5.2: Typical representation of machine guards to avoid the mechanical hazards.

Miscellaneous safeguarding aids:

- Shields can be used to provide protection from flying particles, splashing metal working fluids or coolants.
- Holding tools can be used to place and remove stock. Example, reaching into the danger area of a power press.
- Holding tools must not be used as a replacement of machine guards.

5.4 SAFETY PRECAUTIONS WHILE WORKING WITH MACHINERY

- Ensure that the guards are in position and in good working condition before operating.
- Know the location of emergency stop switch.
- Do not wear loose clothing or jewellery that can be caught in the rotating parts.
- Confine long hair.
- The keys and adjusting wrenches must be removed from the machine before operating it.
- Stop the machine before measuring, cleaning or making any adjustments.
- Do not handle metal turnings by hand as they can cause injury. Use brush or rake to remove turnings.
- Keep hands away from the cutting head and all moving parts.
- Cutting tools and blades must be clean and sharp, so that they can be used without force.
- Avoid awkward operations and hand positions. A sudden slip could cause the hand to move into the cutting tool or blade.
- Keep work area clean. Floors must be level and have a non-slip surface.

- There must be enough space around the machine to do the job safely.
- The person working with the machine must not be distracted.
- Machines must not be left unattended. Switch off the machine before leaving.
- Rotating parts of machines must not be stopped with hands after switching off.
- Compressed air must not be used to clean machines, as this can force small particles to fly off and can cause injury.

A. PERSONAL PROTECTIVE EQUIPMENT

- Safety glasses must always be used while working with machinery for protection from flying particles.
- Safety glasses must be worn by all personnel entering an area where machines are operated.
- Ear protection must be worn for protection from high noise.
- Safety shoes must be worn if there is handling of heavy materials.
- Hand gloves must NOT be used while working with machinery, due to the chances of getting caught in the nip point.

B. LOCKOUT-TAGOUT

Lockout-tagout or lock and tag is a system used to ensure that machines are properly shut off and not started up again before the completion of maintenance or servicing work.

- Hazardous power sources must be isolated before any repair procedure is started.
- Different types of locks are used for locking the machine or the power source in a manner that no hazardous power sources can be turned on.
- A tag is also attached to the locked device indicating that it must not be turned on.

C. RULES FOR MACHINE SAFETY

- Never remove or try to defeat machine safeguards.
- Don’t create new hazards, such as allowing objects to fall into the moving parts or by creating a new pinch point.
- Report problems with machine safeguards to your supervisor immediately.
- Never leave machines unattended with parts still moving. Remember that parts may still be moving after the machine has been turned off.
- Remove guards only when the machine has been locked out and tagged out.

- If possible, lubricate machine parts without removing the safeguard; otherwise, turn the machine off and lock it out before lubricating.
- Operate equipment only when guards are in place and properly adjusted.
- Do not use unauthorized or damaged guards.
- Do not wear loose clothing, jewellery, or long hair around machines—these increase the risk of being caught in the machinery.
- Ask your supervisor if you have any questions about a machine safety or how to work with machine guards safely.

D. RULES FOR PERSONAL SAFETY

- Always listen carefully to the teacher/instructor and follow instructions.
- Do not attempt operate any machinery until you at ensure you know how to use it.
- Ensure that you know how to stop the machine before starting it.
- Do not walk away and leave the machine running.
- Do not run the workshop, you could 'bump' into other students and cause an accident.
- Wear appropriate personal protection - safety glasses, shoes, etc always wear shirts or tight clothes. Do not wear T-shirt, watches, rings, slippers, sandals and lose clothes in workshop.
- Do not wear gloves near rotating machinery.
- Know where the emergency stop buttons are positioned in the workshop. If you see an accident at the other side of the workshop you can use the emergency stop button to turn off all electrical power to machines.
- When attempting practical works all stools should be put away.
- Bags should be put away from machines.
- When learning how to use a machine, listen very carefully to all the instruction given by the teachers/instructor. Ask question, especially if you do not fully understand.
- Never work alone and when you impaired or hurry. This almost always ruins the work, and often results in injury.
- Always be patient.
- Use hand carefully, keeping both and behind the cutting edge.
- Keep hands away from moving rotating machinery.
- Remove all secure anything might get caught in moving machinery.
- Report any damage to machines / equipment as this could cause an accident.

- A brush, hook, or special tools is preferred for removal of chips, shaving, etc. from the world area. Never use your hands to clean cutting - they are sharp.
- Keep your fingers clear to the point of operation of machines by using special tools or devices, such push sticks, hooks, pliers etc.

5.5 SAFE WORK PRACTICES FOR CENTRAL WORKSHOP

A. MILLING MACHINE

- Check where appropriated that the direction of the work piece moment & rotation of cutter is correct.
- Ensure that all cutting tools, work piece, etc. are sure before starting the machine.
- Work piece clamped securely in vice to clamped tightly to the table.
- Before running the machine, the spindle should be rotated by hand to make sure it is clear for cutting.
- Make sure the power is off before charging cutter.
- Always use the cutting fluid for the material being cut.
- Never run the machine faster than the correct cutting speed.
- Ensure that the feed mechanism is disengaged before starting the machine.
- Position guards to deflect chips to a safe area.
- Do not use cracked or damaged cutters.
- Make sure that the machines are fully stopped before taking any measurement.
- Don't place anything on the milling machine table such as wrenches hammers or tool.
- Don't take too heavy a cut or use to rapid a feed.
- Remove the collect tightening wrench immediately after using it
- Do not touch cutter and attempt clear swarf from cutter area while it is rotating.
- Sharp edges or points of tools to be carried or stored, should be protected. Keep hands away from moving/rotating machinery
- Use milling machine spindle break to step the spindle after the power has been turned off.

B. CNC AND MILLING

- CNC machine is by definition computer controlled, and when the program running the moving parts of the machine i.e. the table quill etc. will move as dictated by the program independent of the operator. On dedicated CNC machining centers this causes only minor problems, as the whole of the machining operation is usually confined within a guard.
- Operators use keyboard subject to see on display screen regulation.
- The guard can only be opened if the cutter has stopped.
- It is essential that student receive 'quality' instruction before attempting to use any CNC equipment by machine operators.
- Before entering any code check all coordinate are right.

- CNC router, used for shaping materials such as woods and plastic, has built in extraction. Dust can be very dangerous if inhaled and can also cause eye irritation.
- Common sense applies to the use of all machine including CNC machines. basic safety training regarding working in a workshop in other machines applies to CNC machines as well.

C. FITTING SHOP

The fitting and bench work-plays an important role in engineering workshop. The work carried out of the fitting bench or bench vice or called bench work.

- Keep proper discipline in the shop. do not play with the tools because they bare sharp.
- All files should be fitted with suitable handle at the end of file.
- When using chisels its direction should be kept away from another working person file and hacksaw must never be used without a handle
- hacksaw blade should be kept in good condition, both hands should be kept behind the blade when applying pressure.
- Hammer heads must be kept tightly wedged in place.

D. GRINDING

- Do not use a cracked wheel. Report it to instructor.
- Always wear eye protection during grinding.
- Transparent face guard/eye shield must be fitted to the machine. They must be clean and properly adjusted.
- The work- rest must be as close to the wheel face possible
- The side of straight-sided wheels should never be used for grinding.
- Take care not to leave loose rags etc. near grinding wheel, if you rag is caught in a rotating wheel it can cause the wheel to burst.

E. LATHE MACHINE SHOP

Before operating the centre lathe, even for simple tasks, the operator must undergo safety instruction. This will ensure that he/she how to remain safe when operating the machine. Only competent engineers should operate the lathe unsupervised.

- Ensure that the entire machine parts of lathe i.e. carriage, tool post, tail stock are in correct position before starting the machine.
- Check, that the direction of rotation of the work piece or cutting tool is correct.
- Ensure that thread cutting and feed mechanisms (lead screw, feed shaft & lock nut) are in natural before starting the machine
- Always remove the chuck key after tightening the job from the lathe chuck.
- Do not use cracked or damaged tools. Keep all tools sharp. Always use the correct tool for the job.
- Keep the lathe -bed clear: do not allow a build -up of swarf.
- The correct size spanner to fit the nut or bolt head should always be used.

- Keep the hand away from moving /rotating machinery. Ensure that long hair is restrained.
- Use hand tool carefully, keeping both hands behind the cutting edge.
- The metal being machined should extrude from the chuck, only small distance. The more metals extruding from the chuck, the more likely an accident will take place.
- The machine must be set to operate at speeds and feed recommended for the specific metal being machined if the metal rotates too slowly /fast or the feed is too slow/fast, accidents are likely to occur.
- Appropriate coolants should be applied to the material begin' turned' on the lathe.

F. SHEET METAL SHOP

- Sheet cutter is use with handle of care.
- When using rolls and bending machines, care should be taken to prevent fingers etc. being caught in the mechanism.
- Bending machine should be left in the closed position when not in use.
- Lever shears should always be fitted with a locking arm to prevent the lever from being accidentally operated when not in use.
- Hammer head must be kept tightly wedged in place.
- Always wear gloves: a simple cut can become a serious infection.

G. METAL CASTING

- Wear eye protection, gloves, spats (covering top of feet), and thick clothing protecting all exposed skin on arms and legs. NO polyester or synthetic clothing.
- Sand Floor in pouring area shall be clear of all objects not involved in pouring.
- Clamp or weight up molds that require it.
- Metal added to heat must be free of moisture and impurities.
- Metal added to heat during melt must be preheated.
- Skimmers and other melting tools must be preheated before use.
- Move slowly while removing crucible from furnace and moving to mold.
- Do not look into exhaust during operation.
- Inspect crucibles before use.
- Inspect propane lines.
- Use outdoors only.
- No alcohol or drug use.
- Wear respiratory protection while melting copper-base alloys (brass, bronze).

H. WELDING

- Shop staff approval is required before using any welding equipment.

- Welder, assistants, and anyone else in the welding area shall wear glasses or shields of recommended shades during welding operations.
- The welder is responsible for erecting a screen around the welding area to protect other personnel in the shop from eye injury.
- Exposure of the naked skin to the heat and light radiation from an electric arc should be avoided. The radiations from the arc include infrared and ultra-violet light.
- Goggles do not give adequate protection from the arc. A hand - held shield that covers the head, face, neck, wrist and hands should be use where both hands are needed a head shield should be used, together with gauntlets to protect the hand and wrists.
- Protective clothing should give cover from the throat to the knees.
- Goggles or a face shield must be use when using a chipping hammer to remove slag spatter
- Welding turn leads must be securely connected by bolting or clamping to prevent contact resistance
- Special care with fume extraction must be taken when using shielding gases in a confined space. Argon and nitrogen tend to puddle and displace the oxygen.
- Power tools must not be left on electric - arc - welding bench. Damage may be cause if the welding earth return should become open- circuit.
- Work in progress or newly finished work, left unattended, should be clearly marked “hot “.
- Do not arc weld in wet area.
- Be alert to possible fire hazards. Move the object to be welded to a safe location, or, remove all flammable material from the work area.
- Never weld in the safe area where degreasing or other cleaning operation are performed

I. GAS WELDING

- When turning on a cylinder, the vale should be opened very slowly, whilst doing this, no one should stand in front of the gauges.
- Care must be taken to ensure that there are no gas leaks.
- Heat sources must never be allowed near the cylinder.
- Oil or grease must not be allowed to come in to connect with the cylinder valves or fittings, especially on oxygen cylinder.
- Hoses must be kept in good condition. wheeled traffic must not be allowed to pass over them. They should be kept from sharp edges and hot metal.
- Cylinder valves must close when not use and hoses drained of any remaining gas.
- Appropriate goggles, fitted with the correct filter glass, must be worm.
- Suitable clothing and gloves should be worm where practicable
- Dross from cutting operation should be caught in a metal receptacle.
- Material being cut should adequately supported.
- Care should be taken to insure that off -cut pieces cannot fall and cause injury and damaged.
- Cylinders must be using an upright position and secured to prevent them falling or being knocked over.

- Check the ventilation system before starting to weld and periodically their after to ensure adequate performance welding fumes should not be allowed to get into the rest of shop working area.
- Never use wrenches or tools except those provided by gas cylinder supplier to open valve. never use hammer to open or close valves.

6. COMPRESSED GAS SAFETY

Compressed gases are regularly used in different laboratories for various experimental research work at IIT Mandi. Compressed gases have the potential for creating hazardous working environments. In order to ensure the safety of all its members/researchers, Institute promotes the safe handling and uses of the gases. Following Guidelines provide information on their safe use and apply to all personnel who use or handle compressed gases.

6.1 STORAGE, HANDLING, MOVEMENT REQUIREMENTS:

Store gas cylinders:

- in an upright position.
- within a well-ventilated area.
- separate from empty cylinders.
- with a chain or appropriate belt above the midpoint, but below the shoulder.
- with the cap on when not in use.
- so that the gases with the same hazard class are stored in the same area. Inert gases are compatible with all other gases and may be stored together.
- At least 20 feet away from all flammable, combustible or incompatible substances.

Do not store gas cylinders:

- in exits routes.
- in damp areas; near salt, corrosive chemicals, fumes, heat; or exposed to the weather without a roof housing.
- longer than one year without use.

Handling Requirements:

To safely handle gas cylinders:

- **Never** drag or physically carry cylinders.
- **Never** pick up by the cap.
- **Never** paint a cylinder.
- **Never** leave cylinders in areas where they will be subject to damage from falling objects, corrosion or public tampering.

Lifting and moving requirements:

- Do notuse ropes, chains and slings to suspend cylinders, unless the cylinder was designed for that use.
- Use only suitable cradles or platforms to hold a cylinder when lifting.

- Use a hand-truck designed for the transport of cylinders.
- Secure cylinder caps during transport.

• Elevator Transport

- Do not accompany a compressed gas cylinder containing highly toxic gas on an elevator.
- Place the cylinder in the elevator and press the destination floor.
- Attach a sign to the cylinder, telling others not to use the elevator during the cylinder's trip.

6.2 GENERAL USE REQUIREMENTS

To safely use valves and regulators:

- Be sure that the regulator pressure control valve is closed before attaching it to cylinders.
- **Do not** stand in-line with the regulator and valve outlet when attaching the regulator to the cylinder.
- Close valves on gas cylinders when a system is not in use.
- Remove all pressure from regulators not currently used (by opening equipment valves downstream after the regulators are closed).
- Vent relief valves to a fume hood or ventilated gas cabinet, when using flammable or toxic gases.

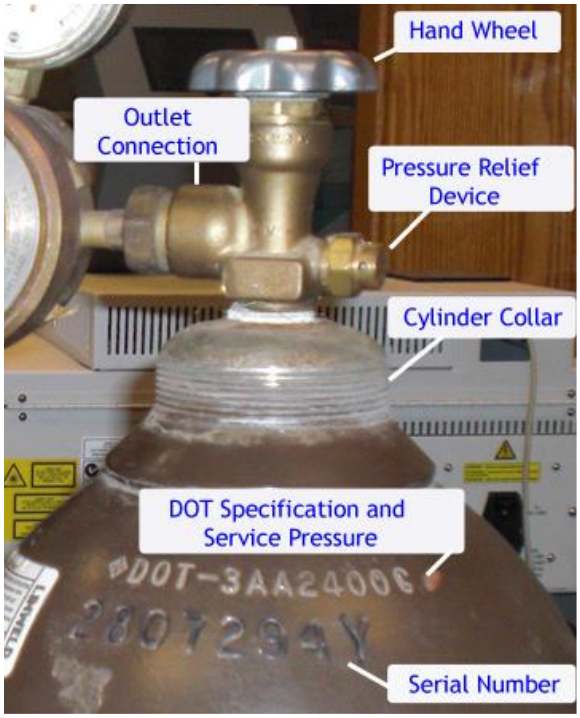

Fig 6.1: Basic parts/components of compressed gas cylinders.

- Pressurize regulators slowly and ensure that valve outlets and regulators are pointed away from all personnel when cylinder valves are opened.
- Leave the wrench in place on the cylinder valve, when needed, to open the main valve.
- Fully open valves during cylinder use. A fully open valve improves the internal seal and helps prevent packing leaks.
- Use a cylinder cap hook to loosen tight cylinder caps. Never apply excessive force to pry off caps.

To safely use gas cylinders:

- **Never** apply excessive force when trying to open valves.
- **Never** allow flames or concentrated heat sources to come in contact with a gas cylinder.
- **Never** allow a gas cylinder to become part of an electrical circuit.
- **Never** use cylinder gas as a compressed air source.
- **Never** use adapters or exchange fittings between tanks and regulators.
- **Never** use Teflon tape on Compressed Gas cylinder's fittings (straight thread) where the seal is made by metal-to-metal contact. Use of Teflon tape causes the threads to spread and weaken, increasing the likelihood of leaks. Small pieces of tape can also become lodged in the valve mechanism resulting in possible valve failure.
- **Never** attempt to open a corroded valve; it may be impossible to reseal or it may break and release the cylinder's contents.

6.3 SYSTEM CONSTRUCTION AND MAINTENANCE

The following information applies to the use of manifolds, piping, valves and/or regulators:

- Where compressed gas cylinders are connected to a manifold, the manifold and its related equipment, such as regulators, must be of proper design for the product(s) they are to contain at the appropriate temperatures, pressures and flows.
- Use only approved valves, regulators, manifolds, piping, and other associated equipment in any system that requires compressed gas.
- Be sure that pressure gauges on regulators are correct for the pressure of the gas cylinder used.
- Gas threads, configurations and valve outlets are different for each class of gases to prevent mixing of incompatible gases.

SYSTEM MAINTENANCE

The following information applies to the use of system piping, regulators, manifolds

and other apparatuses:

- Keep piping, regulators and other apparatuses gas tight to prevent gas leaks.
- Confirm the connection seal by using compatible leak test solutions (e.g., soap and water) or leak test instruments.
- Release pressure from systems before connections are tightened or loosened and before any repairs.
- Fluorescent light can be used to check for grease or oil in regulators and valves.

VALVE AND REGULATOR MAINTENANCE

- Know the valve and regulator maintenance histories before use.
- Valves and regulators should undergo periodic maintenance and repair as necessary.
- Perform a visual inspection before each use to detect any damage, cracks, corrosion, or other defects.
- Valves that pass visual inspection are still subject to failure. It is critical that toxic or poisonous gases (see Appendix II) are used in ventilated enclosures and have local exhaust ventilation in place for downstream pressure relief valves.
- Long term maintenance or replacement periods vary with the types of gases used, the length of use, and conditions of use. Consult the cylinder, regulator or gas supplier for recommended valve and regulator maintenance schedules.
- Valves and regulators should only be repaired by qualified individuals. Consult valve and regulator manufacturers, gas supply companies, or valve and regulator specialty shops for any repair needs.

LABELING

The following labeling requirements apply to all gas cylinders:

- Use only the vendor label for positive identification of contents of the cylinder. Be aware that color coding may be inconsistent from vendor to vendor.
- Mixed gases must be clearly labeled with the contents of the cylinder.
- Empty cylinders must be labeled with the word “empty.”
- Know the contents of each cylinder you are using. Preferred labeling includes the identity of the material, statement of hazard and the associated signal word. For example, the preferred label for nitrogen would be:

OTHER REQUIREMENTS

- Only the gas supplier is allowed to mix gases in a cylinder.
- Do not use cylinders for any other purpose than holding the contents as received. Damaged or leaking cylinders must be reported to laboratory in-charge immediately.
- Leaking, defective, fire burned, or corroded containers must not be shipped without the prior approval of the supplier.

6.4 LEAKS AND EMERGENCIES

PRE-PLANNING

Despite adherence to cylinder safety practices, accidents involving gases may occur. The amount of damage sustained by personnel and property from these accidents is greatly influenced by the quality of the emergency plan. Users of compressed gas cylinders must be familiar with necessary safety precautions, and possible accident scenarios, appropriate employee responses. Some of the following factors must be included:

- The nature of the operation (e.g., experimental design, equipment used and type of injury that could occur.
- The potential location of a release or spill (e.g., outdoors versus indoors, in a laboratory, corridor or storage area, on a table, in a hood, or on the floor).
- The quantities of material that might be released and the type of containment (i.e., compressed gas tank size, manifold systems, etc.).
- The chemical and physical properties of the compressed gas (e.g., its physical state, vapor pressure and air or water reactivity).
- The hazardous properties of the compressed gas (e.g., its toxicity, corrosivity and flammability).
- The availability and locations of emergency supplies and equipment.
- An Emergency Action Plan that identifies building evacuation routes, emergency telephone numbers, chemical containment procedures, fire extinguisher usage, etc.

MINOR LEAKS

Occasionally, a gas cylinder or one of its component parts may develop a leak. Most of these leaks occur at the top of the cylinder, in areas such as the valve threads, pressure safety device, valve stem, or the valve outlet. To correct minor leaks:

- For non-toxic gases, verify suspected leaks using a gas detector or soapy water solution (a flame should not be used for detection). If the leak cannot be stopped by tightening a valve gland or packing nut, notify laboratory in-charge immediately. **Do not** try to fix a leak on a toxic or highly toxic gas cylinder; instead initiate emergency action procedures.
- For flammable (non-toxic), inert or oxidizing gases (non-toxic), move the cylinder to an isolated, well-ventilated area (within or next to a fume hood), away from combustible materials. **Post signs** that describe the hazard.
- For corrosive and toxic gas leaks, immediately contact laboratory in-charge. **Do not** remove a leaking toxic gas cylinder from a ventilated cabinet.

MAJOR LEAKS

In the event of a large gas release or if an accident takes place, activate the following emergency procedures:

- Evacuate the area, securing entrances and providing assistance to others on the way out.
- Activate building and area fire alarms (or chemical safety alarms if applicable).
- Immediately call security officer and report the incident.

6.5 ACCIDENTS AND EMERGENCIES

- For medical emergencies call security officer.
- Assist persons involved and administer immediate first aid, which may include:
- Washing under a safety shower (in case of burning clothing or chemical exposures)
- Removing contaminated clothing
- Irrigating the eyes at an eyewash station
- Administering cardiopulmonary resuscitation (CPR)
- • Notify personnel in adjacent areas of any potential hazards (e.g., activate building or area alarms).
- • Move injured personnel only if necessary to prevent further harm.

7. RADIATION SAFETY

7.1 X-RAYS

X-rays are generated by a high-energy e-beam impinging on solid surfaces. Therefore, in addition to x-ray generators, all high-energy e-beam equipment's are also potential X-ray sources and all precautions concerning X-rays should be taken. There is no dose of X-rays that may be considered 'safe'. No matter how low the level, X-rays can cause possible damage to body cells. Generally the doses are cumulative, with each exposure adding to the damage of previous exposure. Large X-ray doses may causedeath or injury to central nervous system immediately, or leukemia or cataracts later on. Genetic damage can cause birth defects in future generations.

CAUTION IN OPERATION OF X-RAY EQUIPMENT

X-ray equipment's are generally designed with utmost care for protection of personnel from exposure to X-ray radiation under normal operating conditions. Operation in a manner not specified in the instruction manual may result in exposure to X-rays. Access to high voltages may be required during certain equipment servicing procedures and caution is required to prevent electric shock hazard.

To prevent possible accidents, the following precautions must be taken:

- Operation of X-ray equipment must be conducted by or under the direct supervision of qualified personnel.
- Standard attachments must be shielded as per manufacturer's specifications.
- No modifications should be made unless approved by competent authority.
- The safety interlocks provided with the equipment should be periodically checked.
- Workers in Radiation Areas should wear radiation-monitoring devices.
- Regular maintenance procedure should only be carried out under the direct supervision of the equipment in charge in a manner specified by the manufacturer.

7.2 RF RADIATION

Both the frequency and the power level of radiation generated by RF generators may damage human tissues unless proper shielding is provided. Protection from such radiation is possible by appropriate RF shields, such as, Iron or Mu metal etc.

The maximum recommended level of RF radiation for human exposure as per data available in USA and Canada is 10 mW/cm^2 in the 10 MHz-100 GHz frequency range.

RF radiation levels should be measured regularly with field strength meters in the

vicinity of the equipment's using RF power generators to ensure safe working environment.

7.3 ULTRA-VIOLET (UV) RADIATION

Direct exposure to UV radiation can cause superficial eye damage and burning of the skin. A temporary loss of vision can occur under severe exposures. UV absorbing glass should therefore be placed between the researcher and the UV source. Goggles should be worn and hands and forearms should be protected by cotton garments.

7.4 LASER RADIATION

Because of the concentration of beam energy into small area, laser radiation even at low intensity can cause damage to small areas of retina of the eye, if viewed directly. Laser beams can still be hazardous after being reflected or scattered from intercepting surfaces, Laser radiation, direct or reflected, should not be allowed to enter the eyes.

8. CRYOGENS SAFETY

The cryogenic liquids are vastly used in almost all the research institutes and laboratories. Cryogens liquids are typically defined as a liquid with a normal boiling point below -150 ^{0}C (123°K). The most commonly used are the various gases like Argon (Ar), Helium (He), Hydrogen (H), Nitrogen (N_2), and Oxygen (O_2) in their liquid form. Special care is required for the transportation, handling, and storage of these liquids because of the extremely low temperature. Common cryogens and their properties are summarized below:

Cryogen	Boiling point (1 atm) ^{o}C	Critical pressure psi	Liquid density, g/L	Gas density (@27^{o}C), g/L	Liquid-to-gas expansion ratio	Type of gas
Ar	-186	710	1402	1.63	860	Inert
He	-269	34	125	0.16	780	Inert
H_2	-253	188	71	0.082	865	Flammable
N_2	-196	492	808	2.25	710	Inert
O_2	-183	736	1410	1.4	875	Oxidizer
CH_4	-161	673	425	0.72	650	Flammable

8.1 CRYOGENIC HAZARDS

Most of the safety precautions required for working with compressed gases also applicable to cryogenic liquids. These hazards include frostbite, asphyxiation, embrittlement, pressure buildup, fire and explosion. In addition, Two additional hazards frostbite, asphyxiation are created because of the unique properties of cryogenic liquids:

EXTREMELY LOW TEMPERATURES:

The cold boil-off vapor of cryogenic liquids rapidly freezes human tissue. Many materials such as carbon steel, plastics and rubber become brittle or even fracture under stress at the cryogenic temperatures. Therefore proper material selection is important for the safe working with such materials. Cold burns and frostbite caused by cryogenic liquids can result in extensive tissue damage. Frostbite changes color of the skin to gray or white, possibly followed by blistering. – Deep tissue freezing generally indicated by a waxy and possibly a yellow appearance to the skin.

VAPORIZATION:

All cryogenic liquids produce large volumes of gas upon vaporization. For example, as mentioned in the above table, liquid nitrogen expands 696 times upon vaporization. If these liquids vaporize in a sealed container, they can produce enormous pressures that could rupture the vessel. For this reason, pressurized cryogenic containers are usually protected with multiple pressure relief devices. Vaporization of cryogenic liquids (except oxygen) in an enclosed area can cause asphyxiation. Vaporization of liquid oxygen can produce an oxygen-rich atmosphere, which will support and accelerate the combustion of other materials. Vaporization of liquid hydrogen can form an extremely flammable mixture with air.

8.2 PERSONAL PROTECTION EQUIPMENT (PPE):

- a full faceshield over safety glasses
- cryogenically rated, loose-fitting gloves
- gloves should be loose fitting so that they can be quickly removed
- crogenic gloves are not rated for immersion into cryogenic liquids or for prolonged handling of cryogenically chilled materials
- long-sleeved shirt or lab coat, and pants without cuffs
- safety shoes are recommended for people involved in the handling of containers.

Fig 8.1: Hand gloves (left) and basic protection gears for cryogenic safety.

8.3 CONTAINERS AND TRANSFER LINES

Cryogenic liquids are be transported, stored, and handled in a variety of containers depending on quantity and desired use.

- DEWARS

Dewars are non-pressurized, double walled containers used to contain cryogenic liquids. The area between the walls is under high vacuum for maximum thermal

insulation. They have a loose fitting insulated cap that enable gases to escape while preventing moisture buildup at the neck. Dewar flasks are smaller, double-walled cryogenic storage containers that usually only maintain the liquid for a few hours. They usually have a metal outer wall and a glass inner wall, with the void space under high vacuum. Special care should be taken when handling as these flasks can implode.

Fig 8.2: Various types of cryogenics dewars.

- CRYOGENIC LIQUID CYLINDERS

Cryogenic liquid cylinders are insulated, vacuum jacketed, pressurized vessels. They come equipped with safety relief valves and rupture disks to alleviate pressure buildups. These cylinders come in a variety of sizes ranging from 80 - 450 liters. They can be equipped to provide gas through an internal vaporizer or provide liquid under their own internal vapor pressure. Cryogenic cylinders routinely relieve their internal pressure and you may observe a sudden hissing sound and the appearance of a fog When using cryogenic cylinders, users should ensure that all valves and pressure relief devices are in place and in good condition. If pressure relief devices fail, catastrophic failure may result.

Fig 8.1: Various types of cryogenics gas cylinders.

- TRANSFER LINES

  A liquid transfer line is used to safely remove liquid product from Dewars or cryogenic liquid cylinders. A typical transfer line for Dewars is connected to a bayonet that provides a means of using product vapor pressure build-up or an external pressure source to remove the liquid. For cryogenic liquid cylinders, the transfer line is connected to the cylinder liquid withdrawal valve. Liquid product is typically removed through insulated withdrawal lines to minimize the vaporization of liquid product to gas. Insulated flexible or rigid lines are used to withdraw product from storage tanks. Connections on the lines and tanks vary by manufacturer. Liquid cylinders designed to dispense gases have valves equipped with standard Compressed Gas Association (CGA) outlets. Suitable pressure regulating equipment may be attached. Valves provided for the withdrawal of liquid product are also equipped with standard CGA outlets, but they are different than the connections used for gaseous withdrawal. This is to prevent accidental introduction of liquid into a gas system, or of gas into a liquid system.

8.4 HANDLING CRYOGENIC LIQUIDS

Most cryogenic liquids are odorless, colorless, and tasteless when vaporized. When cryogenic liquids are exposed to the atmosphere, the cold boil-off gases condense the moisture in the air, creating a highly visible fog.

- Cryogenic liquids MUST be used in a well-ventilated area. All cryogenic liquids produce large volumes of gas when they vaporize.
- When used in sealed containers, this vaporization can produce enormous pressures.
- Always wear proper PPE.
- Always use proper containers designed for the transport and use of cryogenic liquids.
- Examine containers and pressure relief valves for signs of defect. Never use a defective container.
- Always handle these liquids carefully to avoid skin burns and frostbite. Exposure that may be too brief to affect the skin of the face or hands may damage delicate tissues, such as the eyes.
- Boiling and splashing always occur when charging or filling a warm container with cryogenic liquid or when inserting objects into these liquids. Perform these tasks slowly to minimize boiling and splashing. Use tongs to withdraw objects immersed in a cryogenic liquid.
- Never touch uninsulated pipes or vessels containing cryogenic liquids. Flesh will stick to extremely cold materials. Even nonmetallic materials are dangerous to touch at low temperatures.
- Use wooden or rubber tongs to remove small items from cryogenic liquid baths. Cryogenic gloves are for indirect or splash protection only, they are not designed to protect against immersion into cryogenic liquids.
- When transferring into a secondary container, do not fill the secondary container to more than 80% of capacity.

- Check cold baths frequently to ensure they are not plugged with frozen.

8.5 EMERGENCY FIRST AID

- People suffering from lack of oxygen should be moved to fresh air. If the victim is not breathing, administer artificial respiration. If breathing is difficult, administer oxygen. Obtain immediate medical attention.
- For skin contact with cryogenic liquid nitrogen, remove any clothing that may restrict circulation to the frozen area. Do not rub frozen parts, as tissue damage may result. As soon as practical, place the affected area in a warm water bath that has a temperature not in excess of 40°C. Never use dry heat. Call a physician as soon as possible.
- Frozen tissue is painless and appears waxy with a possible yellow color. It will become swollen, painful, and prone to infection when thawed. If the frozen part of the body has been thawed, cover the area with a dry sterile dressing with a large bulky protective covering, pending medical care. In the case of massive exposure, remove clothing while showering the victim with warm water. Call a physician immediately.
- If the eyes are exposed to the extreme cold of the liquid nitrogen or its vapors, immediately warm the frostbite area with warm water not exceeding 40°C and seek immediate medical attention.

9. WOERKSPACE AND WORKING AREA

The workspace area and its ambience play very important role on their health and safety and common feeling of the staff/workers. The chances of an accident happening and the health of the worker is greatly affected by it surrounding and working space and working culture. The building and laboratory in-charge should ensure the requirement of space and proper pathway to exit in the case of emergency. Following are the typical issues in the office or laboratory space that adversely affect the health condition, and put of the safety under question.

1. One of the main problems of the most of the workspaces is the insufficient amount of space to move around. Workers may be cramped for space, that can cause stress levels to rise if they get flustered at having no space to work properly.
2. Inadequate workspace can also lead to involve manual handling issues if it does not allow sufficient freedom of movement or requires the employee to sit or stand in an awkward way whilst they work.
3. Besides the sufficient space for office desk space, employees need freedom of movement at their own workstation, they also need enough space to easily be able to move past other workstations and pieces of equipment. This is especially true if their place of work includes dangerous machinery such as cutting apparatus, where if they were to accidentally knock into a person's arm or workbench they could cause that person to suffer a serious injury.
4. A crowded room will have numerous obstructions which will hinder any escape in the event of an emergency evacuation such as an outbreak of fire or the release of a hazardous chemical substance.
5. Workspace should clear of all the obstacles with proper clear pathway to the exit of their office/laboratory and to the exit of the building. Obstructed, narrow and blocked pathways makes workers competing with each other to get to the exit, and increases the time taken to get outside and could be the difference between life and death in the emergency situation.

10. HANDLING EMERGENCY SITUATION (FIRST AID)

- First aid is the first assistance given to injured or sick person before the arrival of an ambulance or a qualified medical/paramedical or before the person is transferred to a health care facility.
- First Aid is not about giving medicine or diagnosing a condition.
- First Aid can be given by anyone, anywhere, anytime to injured and sick person
- Timely First Aid can save life.

FIRST AID IS **NOT**

: about treating a person or giving medication to anyone sick/ injured

:about being a Doctor and diagnosing the problem

PROCEDURE

The procedure of attending an emergency includes the following:

1. Assess the situation – Is it SAFE for YOU as well as others
2. Safety first
3. Alert and seek help by dialling following emergency numbers:
   Medical Unit : 01905-267014
   Ambulance (South Campus) : 8628835180
   Ambulance (North Campus) : 8894237351, 7807474494
4. Take universal precautions for providing first aid
5. Provide first-aid/ Reassurance
6. Transport or refer to a healthcare facility, if needed
7. Hygiene - WASH YOUR HANDS, DISPOSE OF RUBBISH CAREFULLY TO STOP INFECTION SPREAD

- It is important to always check the scene and ensure your safety first.
- Remember that dialling emergency number for ambulance and other related services is one of the most important steps you can take to save another's life.
- Your safety is first, so leave the scene if you are at risk.
- Use preventive breathing barriers / personal protective equipment (PPE) when available.
- Try to cover your own cuts, sores, wounds, and any skin conditions with a proper

bandage before responding.

- Use disposable gloves to avoid direct contact with blood / bodily fluids. In absence of gloves plastic bags or thick pad of cloths can be used as barrier in between.

- Washing your hands properly is extremely important. Always use soap and water after removing your gloves/barrier.
- If you suspect that a victim has suffered a spinal or neck injury, do not move or shake the victim.

DEALING WITH ANEMERGENCY

Emergency situations vary greatly but there are four main steps that always apply:

1. Make sure you are SAFE and the everybody around you is safe.
2. Evaluate the injured person's condition.
3. Seek help.
4. Give first aid.

As a first aider, you should be SAFE:

S - Stop (Stop, Think, Act)

A - Assess (Scene, Hazard, Risk)

F - Find (FA Kit, AED)

E - Exposure Protection (Gloves, Universal Precaution)

- Try to find out what has just happened; - Ask, shout, call
- Look around, up and down for any danger (is there a threat from traffic, fire, electricity cables, etc.?);
- Never approach the scene of an accident if there is possibility of danger to yourself.
- Do your best to protect both the injured person(s) and other people on the scene;
- Mind your safety, and seek emergency help if an accident scene is unsafe and you cannot offer help without putting yourself in danger.

Always apply four main steps systematically during any emergency situations:

i. Safety first – Make sure there is no danger to you and victim.
ii. Check response - is the person asleep or unresponsive – Call, Shake, Shout
iii. Seek help - Shout or call for help if you are alone but do not leave the person unattended.

iv. Quick assessment of victim's condition–Check consciousness and breathing (look, listen, feel). Look for bleeding and other life threatening conditions & take life-saving measures such as:
   - if no breathing, start Chest compression(CPR)
   - If breathing present but unconscious, casualty is placed inside recovery position
   - If bleeding present, stop/control bleeding by direct pressure
   - Immobilize bone/joint injuries and take care when handling or moving to prevent any injury to the spine or neck and protecting casualty from heat/cold

v. Take complete assessment and stabilize the person as per available local resources

The casualty is …	Procedure
Conscious and breathing normally	Give appropriate first aid.
Unconscious, and breathing normally	Put the casualty in recovery position.
Unconscious and not breathing or not breathing normally	Start CPR/chest compressions: Rescue breathing

Unconscious + Breathing = RECOVERY POSITION

Unconscious + Not breathing or not breathing normally = CPR/chest compressions

SEEK HELP

Once you have evaluated the sick or injured person's condition you can decide if help is needed urgently. If help is needed, ask a bystander to call for help.

An ambulance is the best way to transport ill or injured persons, but they are not always and everywhere quickly available. **Always remember the emergency no in your area.**

PROVIDE FIRST AID

When providing first aid, try to protect an ill or injured person from cold and heat. Do not give anything to eat or drink to a person who is severely injured, feeling nausea, becoming sleepy or falling unconscious.

Be aware that experiencing an emergency situation is a very stressful experience for the injured or sick person. To support him through the ordeal, follow these simple tips:

TALK TO THE injured/ sick ……REASSURES this is PSYCHOLOGICAL SUPPORT

- Tell the sick or injured person your name; explain how you are going to help/ whether you know first aid and reassure him. This will help him to relax
- Listen to the person – the casualty can tell you what happened and what is wrong
- Make him as comfortable as possible
- If he/she is worried, tell him that it is normal to be afraid
- If it is safe to do so, encourage family and loved ones to stay with him
- Explain to the sick or injured person what has happened and what is going to happen.

HOW TO OBSERVE RESPONSIVENESS AND CONSCIOUSNESS?

Unconsciousness occurs when a person is suddenly unable to respond to stimuli like sound or pain, and appears to be asleep. A person may be unconscious for a few seconds (as is the case with fainting) or for longer periods of time.

Always react to what you see – you are not a doctor so do not try to diagnose

CHECK RESPONSE: By shouting or asking his name (if you know) or just ask hello how you are from a distance; if victim doesn't responds then go near him and

- By tapping/ shaking (not in trauma patient) /pinching shoulder or any part of body
- By pinching on any body parts
- The **ABC's** of **first aid** are the primary things that need to be checked when you approach the victim, **Airway**, **Breathing**, and **Circulation**. Prior to **CPR**, ensure that the airway is clear, check to see if the patient is breathing, and check for circulation (pulse or observation of colour and temperature of hands/fingers).

How to observe the breathing?

The airway may be narrowed or blocked making breathing noisy or impossible.

It is essential to establish a clear airway immediately. Unblocking the breathing passage takes priority over concerns about a potential spinal injury.

To observe the breathing do following:

1. If the person is unconscious and is not on his back, turn him on to his back.

2. Kneel beside the casualty.

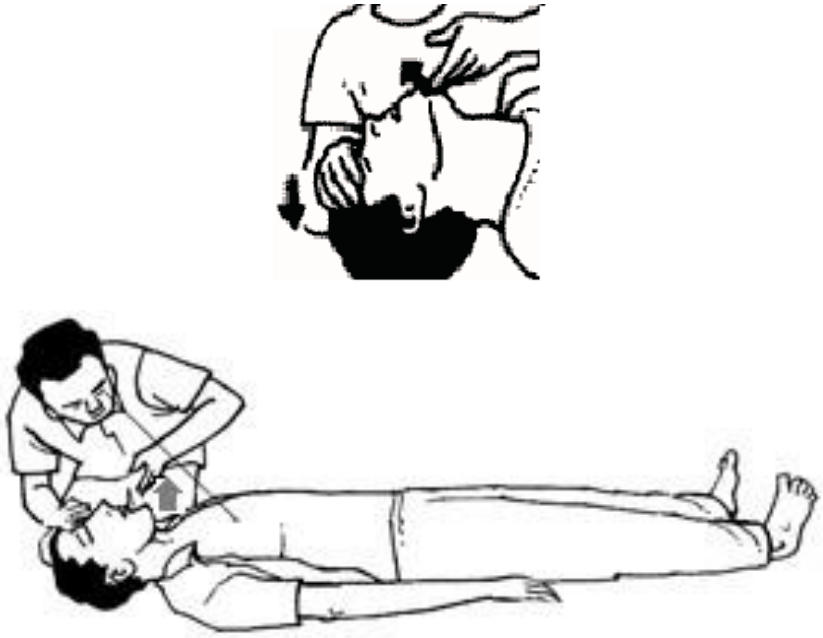

Fig 12.1: Procedure for observation of breath.

3. GENTLY lift the chin forwards (Should be avoided in trauma patient) with the index and middle fingers of one hand while pressing the forehead backwards with the palm of the other hand. This manoeuvre will lift the tongue forward and clear the airways.

4. After opening the victim's airway, check to see if the victim is breathing.
   Observe breathing by listening, feeling and looking. This should be done quickly (max. 10 seconds).
   Place your cheek in front of the victim's mouth (about 3-5 cm away) while looking down his chest (towards his feet).

   You can also gently place a hand on the centre of the victim's chest. This allows you to observe whether the victim is breathing in the following ways:

   a. *look* for chest/abdominal movement,
   b. *listen* to breathing sounds,
   c. *Feel* the air coming out of the nose or mouth.

   In the first minutes after cardiac arrest it often appears as if the person is trying to breathe. It can appear as if the person is barely breathing or is taking in frequent noisy gasps. It is important not to confuse this with normal breathing and you should start chest compressions immediately.

5. If the casualty's chest still fails to rise, first assume that the airway is not fully open. Once the airway is cleared the casualty may begin breathing spontaneously.

   Clear the airway by removing any visible item that is blocking the airway:

   a. Hook your first two fingers covered with clean cloth/gloves.
   b. Sweep round inside the mouth/throat. Only if you can see object clearly
   c. Check again the breathing.

   In case of no indication of breathing in casualty, Start CPR : If alone, start high-quality cardiopulmonary resuscitation (**CPR**) at a **compressions**-to-**breaths** ratio of 30:**2**. If not alone, start high-quality **CPR** at a **compressions**-to-**breaths** ratio of **15**:**2**. ... High-quality **CPR** and changing rescuers every **2** minutes improves a victim's chance of survival.

SKILL SET: FIRST AIDERS ACTION FOR A CASUALTY WHO IS UNCONSCIOUS AND BREATHING

- Kneel down by the side of the casualty
- Put the person on one side doesn't matter left or right, towards you or opposite side (depends on context) but making sure that victim doesn't rollback
- Place the person's arm on the side you are kneeling at right angles to his/her body and bend the forearm upwards with palm facing up
- Lay the person's other arm on his/her cheek on the side at which First Aider is kneeling
- Grasp the leg on the other side of the person's body under the knee and raise that leg keeping the person's foot on the ground
- Pull the raised leg and roll the person towards you so he turns on his side
- Upper leg of the person should place in such a way that his hip and knee are at right angles.
- The person is now in a turned position and will not turn on his back.

In case of Medical Emergency, contact Medical Unit of the Institute immediately on 01905-267014

Note : List of Indian Emergency Helpline Numbers are placed at "Appendix-V".

11. SAFETY REFERENCES/ IMPORTNAT RESOURCES

This manual is prepared using the content from various internet sources and prevailing guidelines in various universities/institutes. Some important reference for safety practices are as follows:

1. Manuals for fire safety: Directorate General Fire Services, Civil Defence & Home Guards: Ministry of Home affairs, Government of India. (https://dgfscdhg.gov.in/mass-awareness-in-print)
2. Disaster Management Plan, Department of Fire, Government of Himachal Pradesh. (https://www.hpsdma.nic.in/WriteReadData/LINKS/DMP%20-%20Dept%20of%20Fire%20Safety%20-%202018dc281fe4-a8f2-47fe-b105-03450e4bded7.pdf)
3. Electrical Safety Hazards Handbook, Electrical safety document Las Alamos National Laboratory, USA (https://www.lanl.gov/safety/electrical/docs/arc_flash_safety.pdf)
4. Chemical Hygiene Plan (CHP), Environment Health Safety Office, Emory University, USA, (http://ehso.emory.edu/documents/ehs-405-chemical-hygiene-plan.pdf)

Additional important reference/web sources which are used for the preparation documents are as follows:

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2. http://www.gutenberg.org/files/20220/20220-h/20220-h.htm
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4. https://www.rajoko.nl/safety/grinding/machine/in/indonesia.html
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6. https://www.ddfire.gov.uk/sites/default/files/attachments/fire-emergency-plan.doc
7. https://en.m.wikipedia.org/wiki/Fire_triangle
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13. https://www.nationwidefireextinguishers.co.uk/co2-fire-extinguisher-help-guides/
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15. https://www.autopro.com.au/drive-fire-extinguisher-1kg-1a20b-e-fw4
16. https://www.keyano.ca/en/about-us/resources/Health-and-Safety-Manual.pdf
17. https://www.abdn.ac.uk/staffnet/working-here/resources-5988.php
18. http://www.safety.uwa.edu.au/incidents-injuries-emergency/procedures
19. https://www.london-fire.gov.uk/media/1174/sign.pdf
20. http://www.hsa.ie/eng/Topics/Fire/Emergency_Escape_and_Fire_Fighting/
21. https://www.lyceeinternational.london/frv2/why-us/nos-rglements
22. http://ee.iiti.ac.in/safety_rules.html
23. https://ehs.princeton.edu/book/export/html/1101
24. https://www.baylor.edu/ehs/index.php?id=92737
25. http://www.ru.ac.za/media/rhodesuniversity/content/safety/documents/Lab_Safety_Manual_Chemistry_2013_RU.docx

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27. http://vvitengineering.com/lab/EE6411-ELECTRICAL-MACHINES-LABORATORY-I.pdf
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46. https://researchsafety.northwestern.edu/safety-information/general-lab-safety/lab-safety-chemical-hygiene-plan/
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91. http://www.ucd.ie/chem/t4media/UCD%20Safe%20Use%20of%20Hydrofluoric%20Acid%20HF%20Manual%20.pdf
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93. https://www.utdallas.edu/ehs/download/Chemical_and_Hazardous_Materials_Safety.pdf
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99. http://www.iitb.ac.in/safety/sites/default/files/Machine%20Safety_0_0.pdf
100. https://www.gruppointerforcejonica.it/37209/grinders/devices_and_crusher_machine_guards.html
101. http://www.ilocis.org/documents/chpt58e.htm
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116. http://eng.ua.edu/wp-content/uploads/2018/11/machine-weld-shop-safety.pdf
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118. https://physics.oregonstate.edu/machine-shop-safety
119. http://www.publicworks.gov.za/PDFs/consultants_docs/Health_Safety_Specification_Generic.doc
120. https://www.wsmr.army.mil/PDF/compressedgassafety.PDF
121. https://publications.ehs.iastate.edu/gascylinder/files/assets/common/downloads/publication.pdf
122. http://www.ehso.emory.edu/content-guidelines/CompressedGasCylinderGuidelines.pdf
123. https://ehs.utk.edu/wp-content/uploads/2018/03/HM-011-Compressed-Gases-and-Cryogens-AppA-Safety-Guidelines.pdf
124. https://www.concoa.com/docs/ADIS/ADI3200A.pdf
125. http://www.safety.gatech.edu/chemical/LabSafetyManual.docx
126. https://www.fhwa.dot.gov/publications/research/infrastructure/structures/98180/ch3/ch3.cfm
127. https://offices.depaul.edu/environmental-health-and-safety/manuals-procedures/Documents/compressed-gas-safety-manual.pdf
128. https://www.gs.unsw.edu.au/policy/drafts/HS920.pdf
129. https://www.ncbi.nlm.nih.gov/books/n/nap12654/ch7/
130. https://www.maulelectric.com/wp-content/uploads/2016/08/Section-44-Compressed-Gas-Cylinder-Program.pdf
131. https://ehs.utk.edu/wp-content/uploads/2017/02/CompressedGasGuidelines.pdf
132. https://www.osha.gov/Publications/OSHA2268/osha2268.html
133. https://publications.ehs.iastate.edu/gascylinder/14/
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135. https://www.oncboces.org/Downloads/Chem%20Hygiene%20plan-PSW%20TEMPLATE.doc
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137. http://www.utdallas.edu/ehs/download/Chemical_and_Hazardous_Materials_Safety.pdf

138. https://risk.uni.edu/sites/default/files/documents/chemical_hygiene_program.pdf
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141. https://www.ccohs.ca/oshanswers/safety_haz/welding/eyes.html
142. https://www.chem.purdue.edu/chemsafety/CHP/2014Spring/Kenttamaa2014CHP.doc
143. https://ehs.princeton.edu/book/export/html/373
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145. https://www.snc.edu/chemicalhygiene/Training/abouthazards/cryogenics.html
146. https://www.ncnr.nist.gov/equipment/cryostats/CryogenSafety.pdf
147. https://www.ru.ac.za/media/rhodesuniversity/content/safety/documents/Lab_Safety_Manual_Chemistry_2013_RU.docx
148. https://ehs.umass.edu/sites/default/files/Cryogenic_Policy_Current_2011_EHS.pdf
149. https://ehs.princeton.edu/book/export/html/184
150. https://ehs.princeton.edu/laboratory-research/chemical-safety/cryogenic-liquids/cryogenic-liquid-storage
151. https://www.airproducts.com/~/media/Files/PDF/company/safetygram-7.pdf
152. http://www.apsusa.biz/grams/safetygram7.pdf
153. https://jtcmodeltrains.com/products/linde-20-standard-tank-container-no-walkway-205215
154. https://www.airproducts.com/~/media/Files/PDF/company/safetygram-8.pdf
155. http://www.tnstate.edu/chemistry/documents/hygiene_plan_chemistry.doc
156. https://ehs.princeton.edu/laboratory-research/laboratory-safety/laboratory-safety-manual/sec7f
157. https://physics.usu.edu/safety/USU-Liquid-Nitrogen-Use-Guidelines.pdf
158. http://mcl-gases.com/pdf/nitrogen.pdf
159. https://www.ceva.us/content/download/44794/844540/version/1/file/Vectormune%20HVT%20IBD%20&%20RISPENS%20Material%20Safety%20Data%20Sheet.pdf
160. https://mcf.tamu.edu/wp-content/uploads/2016/07/LIQUID-NITROGEN.pdf
161. https://issuu.com/beingprepared/docs/are_you_ready
162. https://www.thebcfgroup.co.uk/health-and-safety-pages/health-and-safety-workspace-and-working-area.php
163. https://epdf.pub/parsing-the-turing-test-philosophical-and-methodological-issues-in-the-quest-for.html
164. https://dmse.mit.edu/sites/default/files/imce/research/safety/DMSE_CHP.pdf
165. https://www.ehs.uconn.edu/Chemical/FlammableLiquids-FactSheet.pdf
166. https://ehs.yale.edu/sites/default/files/files/flammable-liquid-sop.pdf
167. https://www.iloencyclopaedia.org/component/k2/item/384-petroleum-refining-process
168. https://www.keyera.com/titanweb/keyera/keyera.nsf/AllDoc/BDF828E563D095BF8725784D0060D0B1/$File/H2S.pdf
169. https://www.hse.gov.uk/fireandexplosion/storageflammliquids.htm
170. https://lsu.edu/ehs/files/SOP_ChemicalStorageGuidelines.pdf
171. http://home.lagrange.edu/healthandsafety/labsafety/topics/highly_reactive_chemicals.htm
172. https://www.klsecurity.com/blog/page/5/
173. http://research.tu.edu/_resources/pdfdocuments/Explosive_Wastes.pdf
174. https://www.ehs.uci.edu/programs/labres/UCSettlement_UCIPlan/ChemicalClassificationList.xlsx
175. http://research.uga.edu/safety/wp-content/uploads/sites/56/2015/01/10_clsm_app_i_1.pdf
176. https://ehs.yale.edu/sites/default/files/files/organic-peroxides-sop.pdf
177. https://docs.vcrma.org/images/pdf/eh/haz-mat/Chemical-Incompatibility-Table-Storage-Recommendations.pdf
178. https://www.kent.edu/compliance/list-incompatible-chemicals-pdf
179. https://www.csuohio.edu/sites/default/files/Practices%20for%20Proper%20Chemical%20Storage.pdf
180. https://www.kent.edu/chemistry/incompatiblechemicallist
181. https://du1ux2871uqvu.cloudfront.net/sites/default/files/file/7%20Incompatable%20Chemical%20list.pdf
182. https://ehs.utk.edu/wp-content/uploads/2017/06/Incompatible-Chemicals-List.pdf
183. https://www.tucsonaz.gov/files/safety/S-014.pdf
184. http://federal.elaws.us/fr/notice/2016-16689
185. http://www.safety.rochester.edu/labsafety/guidelines/cryogenicsafety.html
186. https://www.accessdata.fda.gov/cdrh_docs/pdf14/K142149.pdf
187. https://www.scribd.com/document/187739140/Gas-Cylinder
188. https://up.codes/viewer/alabama/ifc-2009/chapter/35/flammable-gases-and-flammable-cryogenic-fluids
189. http://publications.ehs.iastate.edu/gascylinder/24/
190. https://ehs.berkeley.edu/chemical-hygiene-plan-hazardous-chemicalsmaterials
191. http://www.ilpi.com/msds/ref/toxic.html

Appendix- I

Sample Emergency Escape Plan of a building (One Floor only)

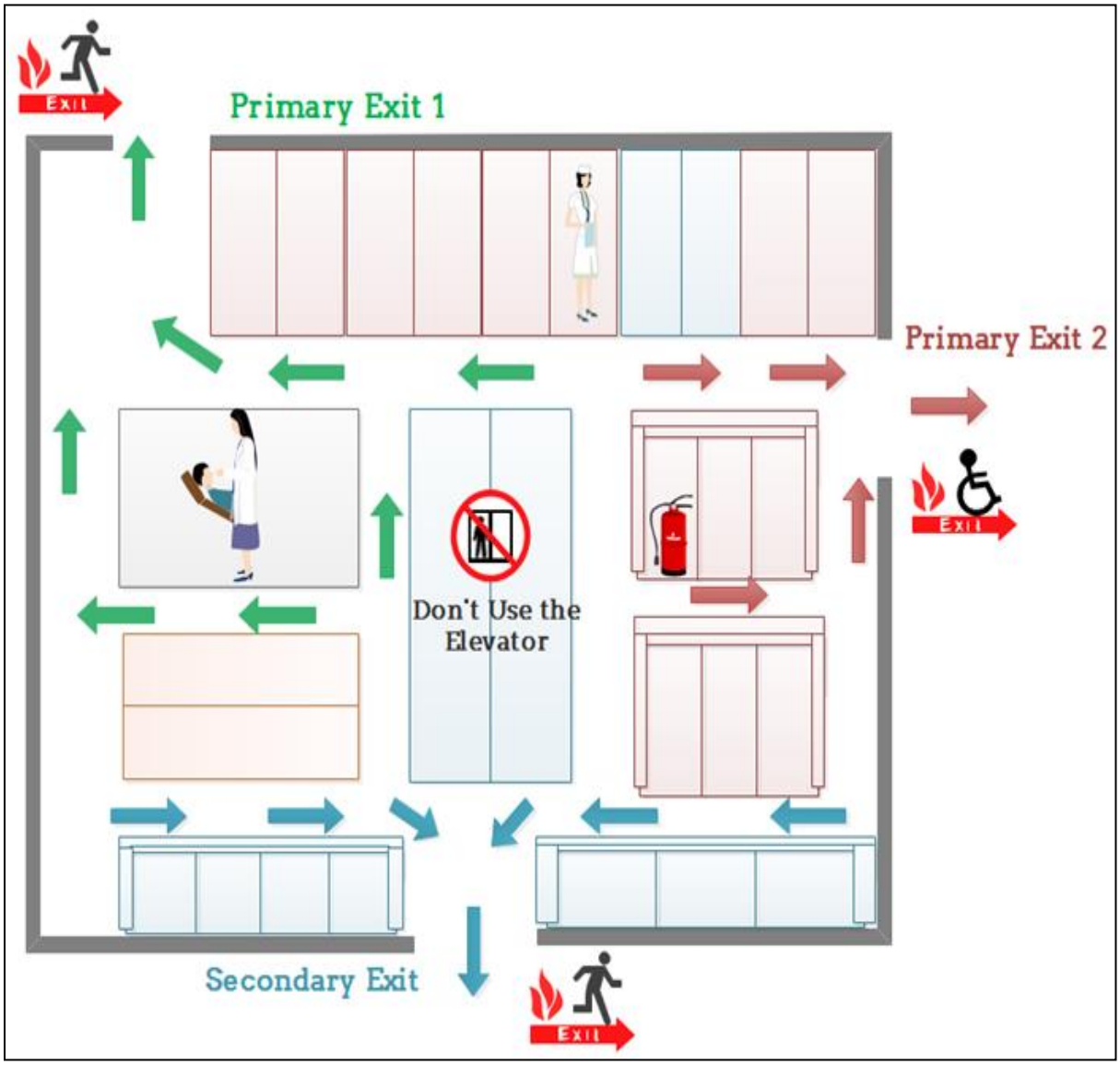

Fig A1: Sample Emergency Escape Plan of a building.

Appendix-II

TABLE

Summary of Quantitative Effects of Electric Currents on Humans

	Direct Current (milliampere)		Alternating Current (milliampere)			
			60 Hz		10,000 Hz	
Effect	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**
Slight sensation on head	1	0.6	0.4	0.3	7	5
Median perception threshold	5.2	3.5	1.1	0.7	12	8
Not painful shock -muscular control not lost	9.0	6.0	1.8	1.2	17	11
painful shock -muscular control not lost by 1/2% volunteers	62	41	9	6	55	37
Painful shock-median “let-go” threshold	76	51	16	10.5	75	50
Painful and server shock-breathing difficult, muscular control lost by 99 1/2 volunteers	90	60	23	15	94	63
Possible ventricular fibrillation*						
-three-second shock	500	500	100	100		
-short shocks (T in Second)			116/□T	116/□T		
-capacitor discharge	50**	50**				

* Estimates based on animal experiments.
** Energy in Joules
* Estimates based on animal experiments.
** Energy in Joules

Appendix-III

HEALTH AND SAFETY INFORMATION FOR WORK WITH CHEMICALS OF SPECIFIC HAZARD CLASS

Flammable Liquids

General Information

Flammable liquids are among the most common of the hazardous materials found in laboratories. They are usually highly volatile (have high vapor pressures at room temperature) and their vapors, mixed with air at the appropriate ratio, can ignite and burn. By definition, the lowest temperature at which they can form an ignitable vapor/air mixture (the flash point) is less then 37.8°C (100°F) and for many common laboratory solvents (ether, acetone, toluene, acetaldehyde) the flash point is well below room temperature. As with all solvents, their vapor pressure increases with temperature and, therefore, as temperatures increase, they become more hazardous. For a fire to occur, three distinct conditions must exist simultaneously: (1) the concentration of the vapour must be between the upper and lower flammable limits of the substance (the right fuel/air mix); (2) an oxidizing atmosphere, usually air, must be available; and (3) a source of ignition must be present. Removal of any of these three conditions will prevent the start of a fire. Flammable liquids may form flammable mixtures in either open or closed containers or spaces (such as refrigerators), when leaks or spills occur in the laboratory, and when heated.

Strategies for preventing ignition of flammable vapors include removing all sources of ignition or maintaining the concentration of flammable vapors below the lower flammability limit by using local exhaust ventilation such as a hood. The former strategy is more difficult because of the numerous ignition sources in laboratories. Ignition sources include open flames, hot surfaces, operation of electrical equipment, and static electricity. The concentrated vapors of flammable liquids are usually heavier than air and can travel away from a source for a considerable distance (across laboratories, into hallways, down elevator shafts or stairways). If the vapors reach a source of ignition a flame can result that may flash back to the source of the vapor.

The danger of fire and explosion presented by flammable liquids can usually be eliminated or minimized by strict observance of safe handling, dispensing, and storing procedures.

Special Handling Procedures

While working with flammable liquids you should wear gloves, protective glasses or goggles, long sleeved lab coats and closed toe shoes. Wear goggles if dispensing solvents or performing an operation that could result in a splash to the eyes. Large quantities of flammable liquids should be handled in a chemical fume hood or under some other type of local exhaust ventilation. Five-gallon containers must be dispensed to smaller containers in a hood or under local exhaust ventilation. When dispensing flammable solvents into small storage containers, use metal or plastic containers or safety cans (avoid glass containers). If splash risk is high wear a face shield in addition to goggles.

Make sure that metal surfaces or containers through which flammable substances are flowing are properly grounded, discharging static electricity. Free flowing liquids generate static

electricity that can produce a spark and ignite the solvent.
Large quantities (five gallons) of flammable liquids must be handled in areas free of ignition sources (including spark emitting motors and equipment) using non-sparking tools. Remember that vapors are heavier than air and can travel to a distant source of ignition.
Never heat flammable substances by using an open flame. Instead use any of the following heat sources: steam baths, water baths, oil baths, heating mantles or hot air baths. Do not distill flammable substances under reduced pressure.
Store flammable substances away from ignition sources. Flammable liquids should be stored inside rated flammable storage cabinets. If no flammable storage cabinet is available store these substances in a cabinet under the hood or bench. Five-gallon containers should only be stored in a storage cabinet that is rated for flammables. You can store flammable liquids inside the hood for short periods of time. However, storage inside chemical fume hoods is not preferred because it reduces hood performance by obstructing air flow.
The volume of flammable liquids kept outside of rated flammable cabinets should not exceed 10 gallons at any one time in the laboratory. Never store containers of flammable liquids or other hazardous chemicals on the floor.
Oxidizing and corrosive materials should not be stored in close proximity to flammable liquids.
Flammable liquids should not be stored or chilled in domestic refrigerators and freezers but in units specifically designed for this purpose. It is acceptable to store or chill flammables in ultra-low temperature units.
If flammable liquids will be placed in ovens make sure they are appropriately designed for flammable liquids (no internal ignition sources and/or vented mechanically). Make sure the autoignition temperature of the solvent is above the oven temperature or its internal elements.

Highly Reactive Chemicals & High Energy Oxidizers

General Information

Highly reactive chemicals include those which are inherently unstable and susceptible to rapid decomposition as well as chemicals which, under specific conditions, can react alone or with other substances in a violent uncontrolled manner, liberating heat, toxic gases, or leading to an explosion.Reaction rates almost always increase dramatically as the temperature increases. Therefore, if heat evolved from a reaction is not dissipated, the reaction can accelerate out of control and possibly result in injuries or costly accidents.
Air, light, heat, mechanical shock (when struck, vibrated or otherwise agitated), water, and certain catalysts can cause decomposition of some highly reactive chemicals, and initiate an explosive reaction. Hydrogen and chlorine react explosively in the presence of light. Alkali metals, such as sodium, potassium and lithium, react violently with water liberating hydrogen gas. Examples of shock sensitive materials include acetylides, azides, organic nitrates, nitro compounds, and many peroxides.

Organic peroxides are a special class of compounds that have unusual stability problems, making them among the most hazardous substances normally handled in the laboratories. As a class, organic peroxides are low powered explosives. Organic peroxides are extremely sensitive to light, heat, shock, sparks, and other forms of accidental ignition; as well as to strong oxidizing and reducing materials. All organic peroxides are highly flammable.
Peroxide formers can form peroxides during storage and especially after exposure to the air (once opened). Peroxide forming substances include: aldehydes, ethers (especially cyclic ether), compounds containing benzylic hydrogen atoms, compounds containing the allylic structure (including most alkenes), vinyl and vinylidine compounds.

Special Handling Procedures

Before working with a highly reactive material or high energy oxidizer, review available reference literature to obtain specific safety information. The proposed reactions should be discussed with the principal investigator or your supervisor. Always minimize the amount of material involved in the experiment; the smallest amount sufficient to achieve the desired result should be used. Scale-ups should be handled with great care, giving consideration to the reaction vessel size and cooling, heating, stirring and equilibration rates.

Excessive amounts of highly reactive compounds should not be purchased, synthesized, or stored in the laboratories. The key to safely handling reactive chemicals is to keep them isolated from the substances that initiate their violent reactions. Unused peroxides should be discarded as hazardous waste and not be returned to the original container.

Do not work alone. All operations where highly reactive and explosive chemicals are used should be performed during the normal work day or when other researcher/students are available either in the same laboratory or in the immediate area.
Perform all manipulations of highly reactive or high energy oxidizers in a chemical fume hood. (Somefactors to be considered in judging the adequacy of the hood include its size in relation to the reaction and required equipment, the ability to fully close the sash, and the composition of the sash.)

Make sure that the reaction equipment is properly secured. Reaction vessels should be supported from beneath with tripods or lab jacks. Use shields or guards which are clamped or secured. If possible use remote controls for controlling the reaction (including cooling, heating and stirring controls). These should be located either outside the hood or at least outside the shield.

Handle shock sensitive substances gently, avoid friction, grinding, and all forms of impact. Glass containers that have screw-cap lids or glass stoppers should not be used. Polyethylene bottles that have screw-cap lids may be used. Handle water-sensitive compounds away from water sources. Light-sensitive chemicals should be used in light-tight containers. Handle highly reactive chemicals away from the direct light, open flames, and other sources of heat. Oxidizing agents should only be heated with fiberglass heating mantles or sand baths.

High energy oxidizers, such as perchloric acid, should only be handled in a wash down hood if the oxidizer will volatilize and potentially condense in the ventilation system. Inorganic oxidizers such as perchloric acid can react violently with most organic materials. Work with large volumes of perchloric acid can only be done in a specially designed perchloric acid wash down hood.

When working with highly reactive compounds and high energy oxidizers always wear the following personal protection equipment: long sleeved lab coats, gloves, closed toe shoes and protective glasses/goggles. During the reaction, a face shield long enough to give throat protection should be worn. A face shield or body shield should be worn in addition to protective eyewear based on the scale of the reaction.

Labels on peroxide forming substances should contain the date the container was received, first opened and the initials of the person who first opened the container. They should be checked for the presence of peroxides before using, and quarterly while in storage (peroxide

test strips are available). If peroxides are found, the materials should be decontaminated, if possible, or disposed of. The results of any testing should be placed on the container label. Never distill substances contaminated with peroxides. Peroxide forming substances that have been opened for more than one year should be discarded. Never use a metal spatula with peroxides. Contamination by metals can lead to explosive decompositions.

Store highly reactive chemicals and high-energy oxidizers in closed cabinets segregated from the materials with which they react, inside secondary containment. You can also store them in the cabinet under a hood. Do not store these substances above eye level or on open shelves. Store peroxides and peroxide forming compounds at the lowest possible temperature. If you use a refrigerator make sure it is appropriately designed for the storage of flammable substances. Store light-sensitive compounds in the light-tight containers. Store water-sensitive compounds away from water sources.

Shock sensitive materials should be discarded after one year if in a sealed container and within six months of opening unless an inhibitor was added by the manufacturer.

List of Shock Sensitive Chemicals

Shock sensitive refers to the susceptibility of the chemical to decompose rapidly or explode when struck, vibrated or otherwise agitated. The following are examples of materials that can be shock sensitive:

Acetylides of heavy metals
Dipicryl sulfone
Lead mononitroresorcinate
Dipicrylamine
Lead picrate
Aluminum ophrite explosive
Erythritol tetranitrate
Lead salts
Fulminate of mercury
Lead styphnate
Amatol
Fulminate of silver
Trimethylolethane
Ammonal
Fulminating gold
Magnesium ophorite
Ammonium nitrate
Fulminating mercury
Ammonium perchlorate
Fulminating platinum
Mannitol hexanitrate
Ammonium picrate
Fulminating silver
Mercury oxalate
Ammonium salt lattice
Gelatinized nitrocellulose
Mercury tartrate
Butyl tetryl
Germane
Mononitrotoluene
Calcium nitrate
Guanyl nitrosamino
Nitrated carbohydrate
Copper acetylide
guanyl-tetrazene
Nitrated glucoside
Cyanuric triazide
Guanyl nitrosaminoguanylidene
Nitrated polyhydric alcohol
Cyclotrimethylenetrinitramine
Nitrogen trichloride
Heavy metal azides
Nitrogen tri-iodide
Cyclotetramethylenetrani
Hexanite
Nitroglycerin
Hexanitrodiphenylamine
Nitroglycide
Dinitroethyleneurea
Hexanitrostilbene
Nitroglycol
Dinitroglycerine
Hexogen
Nitroguanidine
Dinitrophenol
Hydrazinium nitrate

Nitroparaffins
Dinitrophenolates
Hyrazoic acid
Nitronium perchlorate
Dinitrophenyl hydrazine
Lead azide
Nitrourea
Dinitrotoluene
Lead mannite
Organic amine nitrates
Organic nitramines
Organic peroxides
Picramic acid
Picramide
Picratol
Picric acid
Picryl chloride
Picryl fluoride
Polynitro aliphatic compounds
Potassium nitroaminotetrazole
Silver acetylide
Silver azide
Silver styphnate
Silver tetrazene
Sodatol
Sodium amatol
Sodium dinitro-orthocresolate
Sodium nitrate-potassium
Sodium picramate
Styphnic acid
Tetrazene
Tetranitrocarbazole
Tetrytol
Trimonite
Trinitroanisole
Trinitrobenzene
Trinitrobenzoic acid
Trinitrocresol
Trinitro-meta-cresol
Trinitronaphtalene
Trinitrophenetol
Trinitrophloroglucinol
Trinitroresorcinol
Tritonal
Urea nitrate

List of High Energy Oxidizers

The following are examples of materials which are powerful oxidizing reagents:

Ammonium perchlorate
Ammonium permanganate
Barium peroxide
Bromine
Calcium chlorate
Calcium hypochlorite
Chlorine trifluoride
Chromium anhydride or
chromic acid
Dibenzoyl peroxide
Fluorine
Hydrogen peroxide
Magnesium perchlorate
Nitric acid
Nitrogen peroxide
Perchloric acid
Potassiumbromate
Potassium chlorate
Potassium perchlorate
Potassium peroxide
Propyl nitrate
Sodium chlorate
Sodium chlorite
Sodium perchlorate
Sodium Peroxide

Table 1

Class I Unsaturated materials, especially those of low molecular weight, that may polymerize violently and hazardously due to peroxide initiation.	Class II Chemicals which are a peroxide hazard upon concentration (distillation/evaporation).	Class III Peroxides derived from the following compounds may explode without concentration.
Acrylic acid	Acetal	Divinyl ether
Acrylonitrile	Cumene	Divinyl acetylene
Butadiene	Cyclohexene	Isopropyl ether
Chlorobutadiene (chloroprene)	Cyclooctene	Vinylidene
Methyl methacrylate	Cyclopentene	Potassium metal
Styrene	Diacetylene	Potassium amide
Tetrafluoroethylene	Dicyclopentadiene	Sodium amide (sodamide)
Vinyl acetate	Diethylene glycol dimethyl ether (diglyme)	
Vinyl acetylene	Diethyl ether	
Vinyl chloride	Dioxane (p-dioxane)	
Vinyl pyridine	Ethylene glycol dimethyl ether (glyme)	
Vinylidene chloride	Furan	
	Methyl acetylene	
	Methyl cyclopentane	
	Methyl-i-butyl ketone	
	Tetrahydrofuran	
	Tetrahydronaphthalene	
	Vinyl ethers	
Recommended maximum storage time: 12 months	Recommended maximum storage time: 12 months	Recommended maximum storage time: 3 months

Table 2

CHEMICAL	KEEP OUT OF CONTACT WITH
Acetic Acid	Chromic acid, nitric acid hydroxyl compounds, ethylene, glycol, perchloric acid, peroxides, permanganates
Acetone	Concentrated nitric and sulfuric acid mixtures
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali Metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbondioxide, the halogens
Ammonia, anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium Nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids
Bromine	Same as chlorine
Calcium Oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic Acid	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or otherpetroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine Dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene Hydroperoxide	Acids, organic or inorganic
Cyanides	Acids
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic Acid	Nitric acid, alkali
Hydrofluoric Acid	Ammonia, aqueous or anhydrous
Hydrogen Peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases

Hydrogen Sulfide	Fuming nitric acid, oxidizing gases, acetylene, ammonia (aqueous or anhydrous), hydrogen
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric Acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic Acid	Silver, mercury
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Perchloric Acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalies, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium Chlorate	Sulfuric and other acids
Potassium Permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium Peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)
Tellurides	Reducing agents

APPENDIX-IV

Absolute Pressure - Based on a zero pressure reference point, the perfect vacuum. Measured from this point, standard atmospheric pressure at sea level is 14.7 pounds per square inch (psi) or 101.325 kilo Pascals (kPa). This is usually expressed as psia where the 'a' indicates an absolute measurement or kPa.

Asphyxiant Gas - Any non-toxic gas which displaces atmospheric oxygen below limits required to support life. These gases are usually colorless, odorless and tasteless and include, nitrogen, argon and helium.

Compressed Gas - A compressed gas is any gas which when enclosed in a container gives:

An absolute pressure reading greater than 276 kPa (40 psi) at 21°C (70°F) or

An absolute pressure greater than 717 kPa (104 psi) at 54°C (129.2°F) or

Any flammable liquid having a vapor pressure greater than 276 kPa (40 psi) at 38°C (100.4°F).

Compressed Gas Cylinder - A compressed gas cylinder is any metal cylinder of the type approved by the U.S. Department of Transportation (DOT) for storage and transportation of gases under pressure, including liquefied gases. Metal cylinders are the only approved DOT packaging for compressed gases.

Corrosive Gas - A gas that is in contact with living tissue causes destruction of the tissue by chemical action.

Cryogenic Liquid - A liquid with a normal boiling point below -150°C (-238°F).

Cryogenic Liquid Cylinder - Pressurized container designed and fabricated to hold cryogenic fluids. There are three common types of liquid cylinders: gas dispensing; liquid dispensing; or gas and liquid dispensing.

Cylinder Valve - A mechanical device attached to a compressed gas cylinder that permits flow into or out of the cylinder, when the device is in the open position and prevents flow when in the closed position.

Dewar - Is an open-mouthed, non-pressurized, vacuum-jacketed container used to hold cryogenic fluids.

Flammable Gas - A material that is a gas at 68° F (20°C) or less at 14.7 pounds per square inch atmosphere (psia) (101 kPa) of pressure [a material that has a boiling point of 68°F (20°C) or less at 14.7 psia (101 kPa)] which:

Is ignitable at 14.7 psia (101 kPa) when in a mixture of 13 percent or less by volume with air; or

Has a flammable range at 14.7 psia (101 kPa) with air of at least 12 percent, regardless of the lower limit.

The limits specified shall be determined at 14.7 psi (101 kPa) of pressure and a temperature of 68°F (20°C) in accordance with ASTM E 681.

Gauge Pressure - The pressure above or below atmospheric pressure. Therefore absolute pressure minus local atmospheric pressure equals gauge pressure and is usually abbreviated as psig or kPa.

Handling - Moving, connecting or disconnecting a compressed or liquefied gas container under normal conditions of use.

Highly Toxic Gas - A material which produces a lethal dose concentration that falls within any of the following categories:

A chemical that has a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

A chemical that has a median lethal dose (LD_{50}) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare 16 skin of albino rabbits weighing between two and three kilograms each.

A chemical that has a median lethal concentration (LC_{50}) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

High Pressure Gas - A gas in a container that has a pressure of 3448 kPa (500 psig) or higher at 21.1°C (70°F).

Inert Gas - A gas which is chemically inactive.

Liquefied Gas - A fluid within a pressurized container, other than in solution, which exists both as a liquid and gas at 20°C (68°F). Examples include propane, butane, ammonia, carbon dioxide, and sulfur dioxide.

Manifold - A gas distribution system which transfers product through multiple outlets/inlets to or from compressed gas containers.

Nonflammable Gas - A gas which, within the packaging, exerts an absolute pressure of 280 kPa (40psi) or greater at 20°C (68°F) but is not a flammable gas as defined previously.

Oxidizing Gas - A gas that can support and accelerate combustion of other materials.

Poison Gas - Defined by DOT in 49 CFR 173.133. See Toxic Gas.

Pressure Regulator - A mechanical device used to safely control the discharge pressure of a compressed gas from a container.

Pressure Relief Device - A pressure and/or temperature activated device used to prevent the pressure from rising above a predetermined maximum and thereby prevent rupture of a pressurized container.

Pyrophoric Gas - A gas that will spontaneously ignite in air at or below 54.4°C (130°F). Examples include silane and phosphine.

SCF - One standard cubic foot of gas at 21°C (70°F) and 101.325 kPa (14.696 psia).

Storage - Holding of gas, in its packaging, either on a temporary basis or for an extended period in such a manner as to not constitute usage of the gas.

APPENDIX – V

INDIAN EMERGENCY HELPLINE NUMBERS

NATIONAL EMERGENCY NUMBER	**112**
POLICE	**100**
FIRE	**101**
AMBULANCE	**102/108 GVK**
Disaster Management Services	**108**
Women Helpline	**1091**
Women Helpline - (Domestic Abuse)	**181**
Air Ambulance	**9540161344**
Aids Helpline	**1097**
Anti Poison(New Delhi)	**1066 or 011-1066**
Disaster Management (N.D.M.A) : 011-26701728	**1078**
EARTHQUAKE / FLOOD / DISASTER (N.D.R.F Headquaters) **NDRF HELPLINE NO :**	**011-24363260** **9711077372**
Deputy Commissioner Of Police – Missing Child And Women	**1094**
Railway Enquiry	**139**
Senior Citizen Helpline	**1091 , 1291**
Medical Helpline in Andhra Pradesh, Gujarat, Uttarakhand, Goa, Tamil Nadu, Rajasthan, Karnataka, Assam, Meghalaya, M.P and U.P	**108**
Railway Accident Emergency Service	**1072**
Road Accident Emergency Service	**1073**
Road Accident Emergency Service On National Highway For Private Operators	**1033**
ORBO Centre, AIIMS (For Donation Of Organ) Delhi	**1060**
Kisan Call Centre	**1551**
Relief Commissioner For Natural Calamities	**1070**
Children In Difficult Situation	**1098**
All India Institute of Medical Sciences (AIIMS) Poision Control (24*7)	**011-26593677, 26589391, 26583282**
Tourist Helpline	**1363 or 1800111363**
LPG Leak Helpline	**1906**
CORONA HELPLINE	**1075**