College of Energy and Environmental Sciences

Department of Environmental Sciences

Laboratory Safety

Dr. Zaid .M. Joodi

1st&2nd lectures 4th Stage

1. INTRODUCTION

All students, laboratory associates and faculty members should read this document and be aware of safety procedures and restrictions mentioned in this lectures. Students must adhere to written and verbal safety instructions throughout the academic term. Also, it is obligatory for students to attend lab specific trainings.

It should be mentioned here that, along with all the safety measures and precautions, a person's safety depends mostly on herself/himself. Efforts have been made to address situations that may create a hazard in the lab but the information and instructions provided cannot be considered all-inclusive.

1.1. STRUCTURE OF THE HEALTH AND SAFETY PROGRAM

The duties of the LHS committee include the following:

- To identify the potential risks, dangers and hazards in the working area
- To make provision against accidents
- To provide consultancy about occupational health and safety

The backbone of this documentation involves several subjects such as trainings, guidelines on laboratory safety, emergency and waste management procedures.

When using the laboratory equipment and chemicals, an objective analysis of the hazards should be done and a reasonable control of the hazards through the experimental protocol control should be made by means of suitable work practices, ventilation, use of protective clothing etc.

To assess the hazards posed by particular chemicals, the safety datasheet (SDS) of the chemicals should be reviewed and proper conditions of use and necessary precautions should be determined.

2. SAFETY TRAINING

Administrative staff shares the list of new students/employee who will work in the laboratories with laboratory specialist (LS) and laboratory safety specialist (LSS) and informs newcomer to visit LSS. LSS performs the training need analysis with the newcomer, meaning that they decide on the trainings the newcomer will take.

New students/employees get training and have exam depending on an online training calendar which will show all the training and exam dates beforehand. When the exam results are announced, unsuccessful examiners will retake the training session. Successful ones will have the access to the laboratories and he/she will have an orientation in their laboratories with the Responsible Faculty Member / LS / LSS.

A short definition of provided trainings is given below.

2.1. GENERAL LAB SAFETY

This training session covers the environmental health and safety standards and documents, hazards in the laboratories, personal protective equipment, waste disposal, safety signs and emergency situations.

2.2. EMERGENCY MANAGEMENT

This training is covers the emergency response plan, emergency response team, and emergency exit layout.

2.3. WASTE MANAGEMENT

This training is covers identification, handling and disposal procedures for hazardous and non-hazardous waste in the laboratory.

2.4. CHEMICAL SAFETY

Chemical safety training covers the topics of storing chemicals safely, obtaining and managing personal protective equipment (PPE), knowing what training is needed, knowing the hazards of a chemical and disposing of chemicals.

2.5. BIOSAFETY

The training covers biosafety risk levels, biological risks in the laboratory, safety precautions, biological waste disposal and PPE.

2.6. RADIATION SAFETY

Newcomer students and staff should get approval to work with radiation devices, learn to use dosimetry (radiation badge) and view their results, order radioactive materials, and dispose of radioactive waste. Emergencies involving radioactive materials and working with radiation during pregnancy are also the topics of the training.

2.7. LASER SAFETY

Laser safety training is covers the classification of lasers, wavelength range and their pathological effects on the human body and additionally emergency situations.

2.8. COMPRESSED GAS SAFETY

Compressed gases must be handled and used only by trained employees and students. Chemical hazards through a hazard communication program, labels, and other forms of warnings are included in the concept of the compressed gas safety training. Gas manufacturer's safety data sheets (SDSs) should always be consulted for specific information.

2.9. FUME HOOD SAFETY

The training covers information on how to safely operate the fume hoods and instructions for controlling inhalation exposures with ventilation. These instructions are located on the SDS and/or label.

2.10. PERSONAL PROTECTIVE EQUIPMENT

PPE training is covers information about face and eye protection, lab coats and aprons, gloves, foot protection, respiratory protection and how to obtain all the essential PPE.

2.11. CHEMWATCH

ChemWatch Gold FFX is the online software that provides Safety data sheet (SDS) information of all the chemicals, listing and classifying the chemicals that are owned by the faculty.

2.12. ELECTRICAL SAFETY

Hot plates, stirrers, vacuum pumps, electrophoresis apparatus, lasers, heating mantles, ultrasonicators, power supplies, and microwave ovens, named electrically powered eqipments are essential elements of many laboratories. Carriers of even more risk, these devices **have high voltage or high power** requirements.

2.13. MACHINE SHOP SAFETY

When you are operating a machine or a mechanical apparatus, a defensive attitude should be adopted and the working person should be aware of the source of danger or the likely outcome of each sequence of operation.

2.14. MECHATRONICS LAB SAFETY

It is important to prevent accidents or mishaps when operating mechanical equipment. There are general rules and guidelines for the people working in mechanical devices to follow in the laboratory.

2.15. CLEANROOM SAFETY

Before gaining access to the laboratories, all the users must be officially qualified in order to facilitate safe and efficient operation of the cleanroom.

2.16. LABORATORY SPECIFIC TRAINING

In addition to trainings offered, all students and laboratory staff are required to have laboratory specific training on the hazards they may encounter while working.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

3.1. INTRODUCTION

Personal protective equipment is intended to protect lab users from serious workplace injuries or illnesses coming about because of contact with chemical, radiological, physical, electrical, mechanical, or other workplace risks. Along with face shields, safety glasses, helmets, and safety shoes, PPE incorporates an assortment of gadgets and pieces of clothing, for example goggles, coveralls (lab coats, aprons), gloves, vests, earplugs, and respirators.

Performing any operations or experiments, appropriate PPE to wear should be decided and various variables must be mulled over, for example;

- The nature of the hazard and the task
- Compatibility with other PPE
- The chemicals being used, including concentration and quantity
- The hazards posed by the chemicals
- The routes of exposure for the chemicals
- The material the PPE is constructed of
- The permeation and degradation rates specific chemicals will have on the material
- The duration the PPE will be in contact with the chemicals

Careful consideration should be given to the comfort and fit of PPE to ensure that it will be used by the lab users.

Besides, PPE should

- be provided free of charge to users
- be maintained in an efficient working order and in good repair
- be stored in an assigned and suitable area
- be provided in conjunction with appropriate instruction and

training for the user Please see **Table 3.1** for the PPE selection guide by task.

3.2. HAZARD ASSESSMENT

With a specific end goal to evaluate the requirement for PPE the accompanying steps ought to be taken:

3.2.1. *Survey*

In the area being referred to identify sources of dangers, conduct a walk-through survey. Categories for consideration:

- Impact
- Penetration
- Compression (roll-over)
- Chemical
- Heat
- Harmful dust
- Light (optical) radiation
- Drowning
- Falling

Table 3.1 PPE selection guide by task

	If your task/activity involves:	Use the following PPE:
Chemicals	Solids of low or moderate toxicity	▪ Disposable gloves
	Minimal amounts of liquids (less than 0.1 L) with acute or chronic toxicity	▪ Safety glasses or goggles ▪ Appropriate chemical-resistant gloves ▪ Clothing covering to knees
	More than minimal amounts of liquids with acute or chronic toxicity (pure chemicals, mixtures or solutions)	▪ Safety glasses or goggles ▪ Appropriate chemical-resistant gloves ▪ Lab coat ▪ Acid-resistant apron if more than 4 liters of highly corrosive chemicals used ▪ Consider flame-resistant lab coat if more than 4 liters of flammable liquids used
	Cryogenic liquids	▪ Safety glasses or goggles ▪ Face shield required if handling cryovials stored in liquid phase ▪ Insulated cryogenic gloves ▪ Lab coat recommended
	Potentially explosive compounds	▪ Safety goggles ▪ Face shield ▪ Heavyweight gloves ▪ Fire-resistant lab coat

	Pyrophoric (air-reactive) solids or liquids	▪ Safety glasses or goggles ▪ Face shield recommended ▪ Fire-resistant gloves ▪ Appropriate chemical-resistant gloves ▪ Fire-resistant lab coat
	Particularly hazardous substances including carcinogens, reproductive toxins, and reagents of high acute toxicity	▪ Safety glasses or goggles ▪ Appropriate chemical-resistant gloves ▪ Lab coat ▪ Respirators as needed
biological Materials	BL1 microorganisms or viruses	▪ Disposable gloves
	BL2 microorganisms, viruses, viral vectors, human materials or old world primate materials	▪ Disposable gloves ▪ Lab coat
	Procedures outside of the biosafety cabinet without splatter guard when splashes or sprays are anticipated	▪ Safety glasses or goggles ▪ Disposable gloves ▪ Lab coat
Radiation	Unsealed radioactive materials or waste	▪ Safety glasses if there is a splash potential ▪ Nitrile or other appropriate gloves ▪ Lab coat
	Class 3B or 4 laser	▪ Appropriate eye protection
	and if UV laser	▪ Gloves ▪ Lab coat
	Laser(s) modified by optics	▪ Appropriate eye protection
	Open ultraviolet light source ▪ and if face enters UV beam ▪ and if hand enters UV beam ▪ and if body enters UV beam	▪ Safety glasses or goggles with UV protection ▪ UV face shield ▪ Gloves ▪ Lab coat
	Infrared-emitting equipment	▪ Appropriately-shaded goggles ▪ Lab coat
Other Hazards	Handling hot surfaces and objects such as autoclaved materials and heated glassware	▪ Heat-resistant gloves ▪ Lab coat
	Glassware under pressure or vacuum	▪ Safety glasses or goggles ▪ Face shield recommended ▪ Lab coat
	Cutting and connecting glass tubing	▪ Safety glasses or goggles

		▪ Cut-resistant gloves
	Sonicator or other loud equipment	▪ Ear plugs

3.2.2. Sources

During the walk-through survey LSS, the Responsible Faculty Member and the university health and safety specialist should observe:

- Sources of motion; for instance, machinery or procedures where any development of instruments, machine components or particles could exist, or development of work force that could bring about impact with stationary articles
- Sources of high temperatures that could result in burns, eye injury or ignition of protective equipment
- Types of chemical exposures
- Sources of harmful dust
- Sources of light radiation, for instance, welding, brazing, cutting, heat treating, furnaces, and high intensity lights
- Sources of falling objects or potential for dropping objects
- Sources of sharp objects which might pierce or cut the hands
- Sources of rolling or pinching objects which could crush the feet
- Layout of work place and location of co-workers
- Any electrical hazards
- Review injury/accident data to help identify problem areas

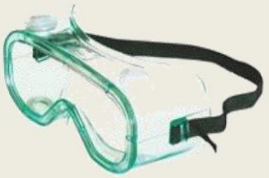
Arrange information. Completing the walk-through survey, it is important to sort out the information and other data acquired. That material gives the premise to peril evaluation that empowers the lab user to choose the proper PPE.

Examine information. Having assembled and composed information with respect to a specific occupation, lab specialist need to assess the potential for wounds. Each of the distinguished hazards ought to be looked into and delegated to its sort, the level of danger, and the reality of any potential injury. Where it is predictable that a representative could be presented to a few perils at the same time, the outcomes of such exposure should be considered.

3.3. EYE AND FACE PROTECTION

On the table below **(Table 3.2)**, eye and face protection equipments can be seen.

Table 3.2 Eye and face protection

Safety glasses	Splash goggles	Laser goggles	Face shields
Safety glasses provide eye protection from moderate impact and particles associated with grinding, sawing, scaling, broken glass, and minor chemical splashes, etc.	Splash goggles provide adequate eye protection from many hazards, including potential chemical splash hazards, use of concentrated corrosive material, and bulk chemical transfer.	The lens of the eyewear is a filter/absorber designed to reduce light transmittance of a specific wavelength. The lens can filter out a specific wavelength while maintaining adequate light transmission for other wavelengths.	Face shields provide additional protection to the eyes and face when used in combination with safety glasses or splash goggles. Face shields consist of an adjustable headgear and face shield of tinted or clear lenses or a mesh wire screen.
			

3.3.1. *Eye Protection*

The use of contact lenses is not recommended while working with chemicals that cause eye irritation.

Eye protection should be worn at all times while working with hazardous chemicals/biological materials or any physical hazards in the laboratory. Visitors should be provided with temporary protective goggles or, at least, protective glasses if they are allowed in any area in which the occupational use of eye protection is required.

Using contact lenses:

In the event of a chemical accident to the eyes, there could be some protection but, on the other hand, the presence of the lens would be an impediment to prompt and thorough flushing of the eyes. The lens would have to be removed which might result in damage to the eye in itself. If, however, the wearer of contact lens conscientiously wears a good-quality pair of goggles at all times when there is a possibility of an incident occuring, there is probably little risk in wearing contact lens. Even in the latter case, where extremely corrosive vapors are likely to be involved, there is a possibility of capillary action causing these vapors to be drawn under the contact lens, and the wearer should exercise caution if there is any suspicion that this could happen.

3.3.1.1. Safety glasses

Safety glasses provide eye protection from moderate effect and particles connected with grinding, sawing, scaling, broken glass, and minor chemical splashes, and so forth. Side defenders are required when there is a risk from flying items. In prescription form for those people requiring corrective lenses, safety glasses are accessible. In the case of safety glasses don't give sufficient insurance to procedures that include substantial synthetic utilize, such as, blending, pouring, or blending, splash goggles should be utilized.

3.3.1.2. Splash goggles

Including potential chemical splash hazards, utilization of concentrated corrosive material, and bulk chemical transfer splash goggles give satisfactory eye protection from numerous dangers. Goggles are available with clear or tinted lenses, fog proofing, and vented or non-vented frames. Be aware that goggles intended for carpentry (can be recognized by the various small holes throughout the face piece) are not fitting for working with chemicals. In the event of a splash, chemicals could enter into these small holes, and result in a chemical exposure to the face. Ensure the goggles you pick are evaluated for use with chemicals.

3.3.1.3. Laser goggles

The lens of the eyewear is a filter/absorber designed to reduce light transmittance of a specific wavelength. The lens can filter out (or absorb) a specific wavelength while maintaining adequate light transmission for other wavelengths.

A single pair of safety glasses is not available for protection from all LASER outputs. The type of eye protection required is dependent on the spectral frequency or specific

wavelength of the laser source. See the **Laser Safety** section for more information.

3.3.2. Face Protection

3.3.2.1. Face shields

When utilized in combination with safety glasses or splash goggles, face shields provide additional protection to the eyes and face. Face shields comprise of a flexible headgear and face shield of tinted or clear lenses or a mesh wire screen. When the whole face needs assurance, they ought to be utilized as a part of operations and worn to shield the eyes and face from flying particles, metal sparks, and chemical/biological splashes. Face shields with a mesh wire screen are not appropriate for use with chemicals. Face shields must not be used alone and are not a substitute for appropriate eyewear and they should always be worn in conjunction with an essential type of eye protection, for example, safety glasses or splash goggles.

3.4. HEAD PROTECTION

Accidents that cause head injuries are difficult to anticipate or control. If hazards exist that could cause head injury, employees should try to eliminate the hazards, but they should also wear head protection.

Safety hats protect the head from impact, penetration, and electrical shock. Head protection is necessary if you work where there is a risk of injury from moving, falling, or flying objects or if you work near **high-voltage** equipment.

Figure 3.1 Head cover

Hard hats **(Figure 3.1)** should be water resistant, flame resistant, and adjustable. Follow these guidelines for head safety:

- Check the shell and suspension of your headwear for damage before each use.
- Look for cracks, dents, gouges, chalky appearance, and torn or broken suspension threads.

- Discard damaged hats or replace broken parts with replacements from the original manufacturer.

3.5. HAND PROTECTION

Most accidents involving hands and arms can be classified under four main hazard categories:

- Chemicals
- Abrasions
- Cuts
- Heat/cold

There are several types of gloves that provide protection against and opposes corruption and pervasion to chemicals. Confiding in the type and concentration of the chemical, performance characteristics of the gloves, conditions and duration of use, hazards present, and the duration of time a chemical has been in contact with the glove, all gloves must be replaced periodically.

Gloves must be worn at any potential danger like chemicals, cuts, lacerations, abrasions, punctures, burns (heat/cold), biological materials, or harmful temperature extremes and when utilizing chemicals that are easily ingested through the skin and/or particularly hazardous. The correct utilization of hand protection can shield from potential chemical and physical hazards.

3.5.1. *Selecting the Proper Gloves*

Proper selection of the glove material is essential to the performance of the glove as a barrier to chemicals/biological materials/physical hazards. Several properties of both the glove material and the chemical/biological material/physical hazard with which it is to be used should influence the choice of the glove. Some of these properties include: permeability of the glove material, breakthrough time of the chemical, temperature of the chemical, type of the possible physical hazard, thickness of the glove material, and the amount of the chemical that can be absorbed by the glove material (solubility effect). Glove materials vary widely in respect to these properties; for instance, neoprene is good for protection against most common oils, aliphatic hydrocarbons, and certain other solvents, but is unsatisfactory for use against aromatic hydrocarbons, halogenated hydrocarbons, ketones, and many other solvents. Please see **Chemwatch** for selecting the proper gloves.

3.5.2. *Double Gloving*

"Double-gloving" is a common practice used with disposable gloves. Twofold layer of assurance is provided by wearing two pairs of gloves on each other. If the outer glove becomes contaminated, starts to degrade, or tears open, until removing and replacing it, the inner glove continues to offer protection. The best practice is to check outer gloves frequently, watching for signs of degradation (change of color, change of texture, tears, etc.). At the first sign of degradation or contamination, always remove and dispose of the contaminated ones immediately and double-glove with a new set. If the inner glove appears to have any contamination or degradation, remove both pairs of gloves, and double glove with a new pair.

It is desirable to double glove with two sets of gloves made from different materials when working with mixtures of chemicals. If one chemical infuses through the outer glove material, the inner gloves can still protect by this method. The type of the glove materials should be chosen depending on the chemical worked with.

3.5.3. *Glove Removal Precautions*

3.5.4. Removing disposable gloves depends on simple rules: Firstly, grab the cuff of the left glove with the gloved right hand and remove the left glove. After that, while holding the removed left glove with the gloved right hand, insert a finger under the cuff of the right glove and gently invert the right glove over the glove in the palm of your hand and dispose of them properly. Finally, wash your hands with soap and water (See Figure 3.2).

Figure 3.2 How to remove gloves

3.5.5. *Types of Gloves*

Table 3.3 represents the types of gloves:

Table 3.3 Types of gloves		
Latex gloves	Resistant to ketones, alcohols, caustics, and organic acids.	
Nitrile gloves	Resistant to alcohols, caustics, organic acids, and some ketones.	
Cryogenic gloves	Cryogenic gloves are used to protect hands from extremely cold temperatures.	
PVA Gloves	Resistant to chlorinated solvents, petroleum solvents, and aromatics.	
Cut-resistant gloves	Cut resistant gloves are gloves designed to protect the wearer's hands from cuts while working with sharp tools.	
Heat-resistant gloves	Working with metal and glass forming and hot surfaces requires gloves that offer the highest level of protection against the multiple hazards of a high-heat workplace.	

3.5.5.1. *Latex gloves*

Natural Rubber Latex - Resistant to ketones, alcohols, caustics, and organic acids.

Due to the fact that latex gloves can degrade severely in seconds while in use with common chemicals, the use of them are not really encouraged. Latex contain several proteins, so latex gloves can also result in allergic reaction in some users. Symptoms can include nasal, eye, or sinus irritation, hives, shortness of breath, coughing, wheezing, or unexplained shock. Using latex gloves should be stopped if any of these

symptoms become apparent.

The use of latex gloves is only appropriate for:

- Most biological materials.
- Non-hazardous chemicals.
- Cleanroom requirements.
- Medical or veterinary applications.

Very dilute, aqueous solutions containing < 1% for most hazardous chemicals or < 0.1% of a known or suspected human carcinogen.

3.5.5.2. Nitrile gloves

Nitrile - Resistant to alcohols, caustics, organic acids, and some ketones.

3.5.5.3. Cryogenic gloves

Cryogenic gloves are used to protect hands from extremely cold temperatures. These gloves should be used when handling dry ice and when dispensing or working with liquid nitrogen and other cryogenic liquids. For further information please consult **Cryogenic Safety** section.

3.5.5.4. PVA gloves

Polyvinyl alcohol (PVA) - Resistant to chlorinated solvents, petroleum solvents, and aromatics.

3.5.5.5. Cut-resistant gloves

Cut resistant gloves are gloves designed to protect the wearer's hands from cuts while working with sharp tools.

3.5.5.6. Heat resistant gloves

Thermal safety is also another part of personal protective equipment. Working with metal and glass forming and hot surfaces requires gloves that offer the highest level of protection against the multiple hazards of a high-heat workplace.

3.6. PROTECTIVE CLOTHING

Loose or torn clothing should be avoided without wearing a lab coat because of the ignition, absorption, and entanglement in machinery risks.

Dangling jewellery, finger rings or other tight jewellery and excessively long hair should also be avoided.

3.6.1. Lab Coats

When properly used, lab coats **(Figure 3.3.a):**

- Provide protection of skin and personal clothing from incidental contact and small splashes.
- Prevent the spread of contamination outside the lab (provided they are not worn outside the lab).
- Provide a removable barrier in the event of an incident involving a spill or splash of hazardous substances.

There are no design or test criteria specified in regulations or guidelines specific to lab coats. What this means is that:

- Lab coats are not tested for normal conditions that may be experienced in a research lab with respect to chemical use, or joined research activities.
- Manufacturers of the lab coats do not provide information about the capability of a lab coat for a combination of hazards. If a coat is "flame resistant", it may not be chemical resistant or acid resistant.
- If a coat is sold as flame resistant, this means it is not tested involving flammable chemicals on the coat. The flame resistance test criteria includes simulation of the possibilities of a flash

  fire, or electric arc flash, not a chemical fire. "Flame resistant" term refers to the characteristic of a fabric that avoids burning in air.

Figure 3.3 Lab coat (a) and apron (b)

Lab coats should be provided for protection and convenience. They should be worn at all times in the lab areas. Due to the possible absorption and accumulation of chemicals in the material, lab coats should not be worn in the lunchroom or elsewhere outside the laboratory.

3.6.1.1. Choosing the right lab coat

Lab coats are made of different materials, and depending on the type of hazard in the lab, it is significant to select the lab coat. Determination of the type of hazard in the lab is the first step in this selection process.

Some questions to consider are the following:

- Do you primarily work with chemicals, biological agents, radioisotopes, or a mix of things?
- Are there large quantities of flammable materials (>4 liters) used in a process or experiment?
- Are there water reactive or pyrophoric materials used in the open air, e.g. in a fume hood instead of a glove box?
- Are there open flames or hot processes along with a significant amount of flammables?
- How are hazardous chemicals used and what engineering controls are available, e.g. a fume hood or glove box?
- Is there a significant risk of spill, splash or splatter for the tasks being done?
- What is the toxicity of chemicals used and is there concern about careless spread of contamination?

One coat may not work for all lab operations. Users might need to provide a basic poly/cotton mixture coat for most operations, but have accessible lab coats of treated cotton or Nomex for work involving pyrophoric materials, extremely flammable chemicals, extensive amounts of flammable chemicals, or work around hot procedures or operations. If there is a possibility of a chemical splash, rubber apron over the flame resistant lab coat should also be used.

3.6.1.2. Flame resistant (FR) lab coats

Work with pyrophoric, spontaneously combustible, or extremely flammable chemicals presents an especially high potential for fire and burn risks to the skin. The use of fire retardant or fire resistant (FR) lab coats is recommended to provide additional skin protection where the individual will be working with these chemicals. The primary materials used for FR lab coats are FR-treated cotton or Nomex.

3.6.1.3. Lab coat use

When lab coats are in use, the following should be observed:

- Wear lab coats that fit properly. Lab coats are available in a variety of sizes. Some lab coat services also offer custom sizes (e.g., extra long sleeves, tall, or woman's fit). Lab coats should fasten close to the collar to provide optimal protection.

- Lab coats should be worn fully buttoned or snapped with sleeves down.
- Wear lab coats only when in the lab or work area. Remove lab coats when leaving the lab/work area to go home, to lunch, to the restroom, or meetings in conference rooms, etc.

Laundry services are not equipped to handle significant contamination of lab coats with hazardous materials. In the event of a significant **spill** of a hazardous material on the lab coat, remove the coat immediately. If skin or personal clothing is impacted, it will be necessary to proceed to an emergency shower. Remove any contaminated clothing, and shower. Generally, significantly contaminated coats and clothing will be considered a **hazardous waste**, and must be managed based on the type of contamination.

3.6.1.4. Lab coat cleaning

Lab coats must not be cleaned at home. For lab coat cleaning, please contact LS.

3.6.2. Aprons

In the case of some procedures in the laboratory, such as washing glassware, large quantities of corrosive liquids in open containers are handled. In this situation, plastic or rubber aprons should be worn over the lab coat.

A high-necked, calf- or ankle-length, rubberized laboratory apron (See **Figure 3.3.b**) or a long- sleeved, calf- or ankle-length, chemical- and fire-resistant laboratory coat should be worn whenever laboratory manipulation or experimentation is conducted.

3.7. RESPIRATORY PROTECTION

A respirator is a device designed to protect the wearer from inhalation of harmful substances. When chosen correctly and used properly, respirators can protect the wearer from,

- Fumes and smokes (welding fume)
- Harmful dusts (lead, silica, and other heavy metals)
- Gases and vapors (chemical exposures)
- Oxygen deficiency (oxidation, displacement, and consumption)
- Biological hazards (tuberculosis, whooping cough, flu viruses)

3.7.1. Inspection

Users must inspect their respirators before and after use. Respirator inspections must

include checking that;

- Sealing surface are clean and free of cracks and holes
- Rubber and elastic parts have good pliability and no signs of deterioration
- Inhalation and exhalation valves are clean and seated properly
- Straps are sufficiently elastic and free of worn areas
- If full face, face shield is cleaned and clear (no smudges, scratches, or other damage that may impede visibility)

Respirators that fail an inspection must be removed from service and replaced.

Before using a respirator, the wearer must perform a positive and negative pressure check. The wearer must ensure current facial condition will allow an effective seal (for example the wearer must be clean shaved).

Positive pressure check. Close off the exhalation valve with palms and exhale gently. No leakage outward around the seal should occur.

Negative pressure check. Close off the cartridges and inhale. The respirator should collapse slightly on the face. No leakage around the face seal should occur while maintaining a negative pressure inside the respirator for several seconds.

3.7.2. Maintenance

3.7.2.1. Cleaning

Respirators must be cleaned and disinfected after each use as follows:

- Remove filters or cartridges.
- Disassemble and wash with mild dishwashing detergent in warm water, using a soft brush.
- Thoroughly rinse to remove any detergent residue.
- When the cleaner used does not contain a disinfecting agent, respirator components must be immersed for two minutes in a sodium hypochlorite (30 mL household bleach in 7.5 L of water) solution, or other disinfectant. The solution used to clean the respirator(s) should contain some type of biocide for disinfection. Rinse in fresh, warm water.

Do not use organic solvents to clean a respirator or high heat to dry it, as this may damage the elastomeric face piece.

3.7.2.2. *Cartridges and filters*

- Change cartridges and filters according to the specific schedule provided with the authorization, or sooner if you experience an increased resistance in breathing or when you detect contaminant odors or taste while wearing your respirator.
- General guidance for organic vapor cartridges. Lab users who use respirators intermittently and perhaps in different environments should never reuse organic vapor cartridges after one use. This is due to chemical desorption of the vapors/gases and their migration through the cartridge charcoal bed. When this occurs, contaminants could be inhaled by the respirator wearer upon initial donning and the concentration could even be higher than contaminant concentrations found in the ambient workplace atmosphere.

3.7.2.3. *Replacement and repairs*

Repair of respirators may be done only by experienced personnel with parts designed for the specific respirator needing repair. No attempt may be made to replace parts or to make adjustments or repairs beyond the manufacturer's recommendations.

3.7.3. *Storage*

- Store respirators away from dust, sunlight, heat, extreme cold, excessive moisture, damaging chemicals, or contamination.
- Filters and cartridges must be removed from the respirator and stored in separate bags to prevent cross contamination.
- Do not store items on top of respirators, which could deform the shape of the face piece.
- Do not store respirators in such places as lockers or tool boxes unless they are on a separate shelf or in carrying cases or cartons to preserve the shape of the face piece.
- Respirators must be packed and stored according to the manufacturer's instructions.
- Never store a respirator within a fume hood or at a work bench where contaminants are present.

3.7.4. *Maintenance and Care of Dust Masks*

Dust masks must be maintained in a clean and sanitary condition. Users who wear dust masks must

- Store dust masks in a plastic bag or box in a secure location such as a locker or desk drawer, away from moisture and contamination.

- Not share dust masks with others.
- Not use a dust mask that is torn, distorted, or dirty.

3.7.5. Types of Masks

Table 3.4 displays the types of masks:

Table 3.4 Types of masks		
Dust mask	The use of the term “dust” mask for the non-rigid soft felt mask is somewhat of a misnomer since, in modified forms, they can be used for other applications such as limited protection against paint fumes, moderate levels of organics, acid fumes, mercury, etc., although their biggest use is against nuisance dust.	
Half face respirator	The half-face cartridge respirator is the type most frequently used, especially in atmospheres in which there is little or no problem of irritation or absorption of material through the skin.	
Full face respirator	Full-face air-purifying respirators are similar in many respects to half-face respirators, with the obvious difference that the mask covers the upper part of the face, protecting the eyes.	

3.7.5.1. Dust mask

The use of the term “dust” mask for the non-rigid soft felt mask is somewhat of a misnomer since, in modified forms, they can be used for other applications such as limited protection against paint fumes, moderate levels of organics, acid fumes, mercury, etc., although their biggest use is against nuisance dust.

These units are the simplest form of the air-purifying respirator. These respirators normally should not be employed for hazardous dusts, but are helpful for exposures to inert or nuisance dust levels below 15 mg/m^3.

3.7.5.2. Half face respirator

The half-face cartridge respirator is the type most frequently used, especially in atmospheres in which there is little or no problem of irritation or absorption of

material through the skin. The face piece of most of these units is molded of a flexible plastic or silicone rubber, which provides a seal to the face when properly adjusted. As noted earlier, facial hair between the mask and the face will prevent the seal from being effective, and it is not permitted for a person with a beard or extended sideburns in the area of the seal to be fitted with a respirator. Accommodation for individuals who wear glasses also must not break the seal to the face. The face pieces of most brands of these units are provided with receptacles for two sets of cartridges and/or filters. The respirators are certified as complete units, *i.e.,* the face piece equipped with specific filters. Cartridges from one vendor cannot be used on another manufacturer's face piece. The major advantage of this type of unit is that by interchanging cartridges and filters, or by using one or more additional filters and cartridges in series, a single face piece can be adapted to provide protection against a large variety of contaminants.

3.7.5.3. Full face respirator

Full-face air-purifying respirators are similar in many respects to half-face respirators, with the obvious difference that the mask covers the upper part of the face, protecting the eyes.

If you work in a high noise area, wear hearing protection. Most hearing protection devices have an assigned rating that indicates the amount of protection provided.

3.8. HEARING PROTECTION

Depending on your level of exposure, you may choose from the following devices **(Figure 3.4):**

- Disposable earplugs
- Reusable earplugs
- Headband plugs
- Sealed earmuffs

Earplugs may be better in hot, humid, or confined work areas. They may also be better for lab users who wear other PPE, such as safety glasses or hats. Earmuffs, on the other hand, may be better for users who move in and out of noisy areas, because the muffs are easier to remove. Before resorting to hearing

protection, attempt to control noise levels through engineering or operational changes. To avo contamination, follow these guidelines when using earplugs:

- Wash your hands before inserting earplugs.
- Replace disposable earplugs after each use.
- Clean reusable earplugs after each use.

Figure 3.4 Headband/ear muff and ear plug

In laboratories, laboratory support areas, and other areas where chemical, biological and physical hazards are present, foot protection should be supplied at all times. Wearing sandals or similar types of perforated or open-toed shoes when working with or around hazardous chemicals or physical hazards must be avoided.

3.9. FOOT PROTECTION

This is due to the potential exposure to toxic chemicals and the potential associated with physical hazards such as dropping pieces of equipment or broken glass being present. In general, shoes should be comfortable, and leather shoes are preferable to cloth shoes due to the better chemical resistance of leather compared to cloth. Leather shoes also tend to absorb fewer chemicals than cloth shoes. However, leather shoes are not designed for long term exposure to direct contact with chemicals. In such instances, chemically resistant rubber boots are necessary.

In some cases, the use of steel-toed shoes **(Figure 3.5)** may be appropriate when heavy equipment or other items are involved. Chemically resistant boots or shoe covers may be required when working with large quantities of chemicals and the potential exists for large **spill**s to occur.

Figure 3.5 Steel-toed shoes and shoe cover

College of Energy and Environmental Sciences

Department of Environmental Sciences

Laboratory Safety

Dr. Zaid .M. Joodi

3rd lectures 4th Stage

4. ENGINEERING CONTROLS AND LABORATORY EQUIPMENT

After hygiene, engineering controls are the next most important means of controlling exposure to hazards. Engineering controls are anything that is built or installed to separate people from chemical, biological or physical hazards, and can include fume hoods, biosafety cabinets, glove boxes, local exhaust ventilation, safety shields, and proper storage facilities.

Hazardous chemicals should be handled and ventilated differently from general laboratory ventilation. Laboratory users should be aware of their chemicals using SDS, how to protect themselves and laboratory environment from hazardous exposures and consider the available engineering controls.

LS/LSS are responsible of keeping functional and maintenance of fume hood and other protective equipment. Infrastructure and emergency equipment such as emergency eye wash and showers, fire extinguishers and ventilation managed by Operation and Technical Services unit. However; laboratory users has responsibility of reporting the malfunctioning equipment as soon as malfunction realize.

4.1. FUME HOODS

Fume hoods are used to prevent hazardous and odorous chemical exposure release to laboratory, laboratory users and the user. Another substantial reason is limiting spill-affected area within hood and exhausting affected air. Inward air flow through the hood minimized material leakage out of the hood.

Fume hoods are substantial infrastructure element for handling hazardous materials . They should not be misused for the purposes such as garbage, storage of materials, equipment.

A fume hood should be used if a proposed chemical procedure exhibits any one of the following characteristics:

- Airborne concentrations might approach the action level (or permissible exposure limit) (see SDS from **ChemWatch**)
- Flammable vapors might approach one tenth of the lower explosion limit (see SDS from (**ChemWatch**)
- Materials of unknown toxicity are used or generated
- The odor produced is annoying to laboratory occupants or adjacent units Procedures that can generally be carried out safely outside the fume hood include those involving the following:
- Water-based solutions of salts, dilute acids, bases, or other reagents
- Very low volatility liquids or solids

- Closed systems that do not allow significant escape into the laboratory environment
- Extremely small quantities of otherwise problematic chemicals.

The fume composed of several elements which are given below:

Face – Sash – Baffles – Duct –Air foil

4.1.1. Types of Hoods

Variable Air Volume (VAV) – VAV hoods maintain a constant velocity as the sash moves but changes the volume of air.

Standard or Bypass – Air volume varies according to the movement of the sash so that as the sash lowered the velocity decreases.

Auxiliary Air – These hoods additional air-injecting blower at the face of the hood. Auxiliary air type hoods are out-of-use owing to their lower performance than VAV and bypass hoods.

Ductless hoods – These hoods are not ducted to outside air but remove contaminants from the air and return it back to the room.

Clean hoods – Clean hoods are sometimes called laminar hoods but these are different from the type of hood mentioned below.

Design of these hoods are based on preventing the work area with HEPA filtered air from contamination. **Figure 4.1 and 4.2** show the effect of material placement to working conditions:

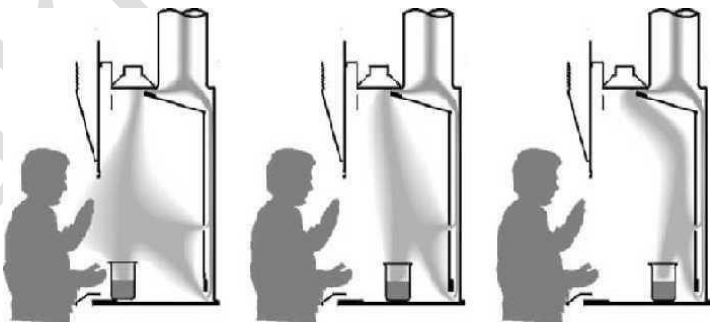


Figure 4.1: Effect of material placement: (L to R) bad placement, good placement, best placement

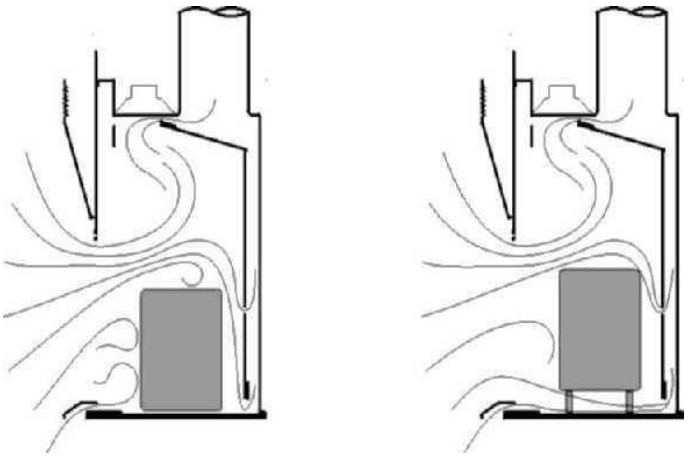


Figure 4.2: Effect of large equipment placement: (L to R) poor placement, and good placement

4.2. OTHER CAPTURE OR CONTAINMENT DEVICES

4.2.1. *Biosafety Cabinets and Laminar Flow Hoods*

Biosafety cabinets (BSC) are intended to protect the user from hazardous aerosols and are equipped with high efficiency particulate air (HEPA) filters that frequently recirculate air back into the lab. They are not capable of capturing hazardous gases and their baffles and inner workings are not generally chemical resistant. Using a BSC with a hazardous gas could not only ruin the cabinet, but it could result in injury to the user. Proper use of BSCs is described in the **Biological Safety** section.

Laminar flow hoods (LFHs) are work benches that continuously bathe the work area with clean, filtered air. Their primary purpose is to protect whatever is being worked on, or "product", not the user. Some laminar flow hoods are also chemical benches which protect both the user and the products. These benches expel air via an exhaust ventilation system and do not recirculate it back into the lab.

4.2.2. *Local Exhaust Ventilation*

have been designed and installed for specific processes. These include:

4.2.2.1. *Elephant Trunk*

Elephant trunk **(Figure 4.3.a)** is useful for small sources of emissions.

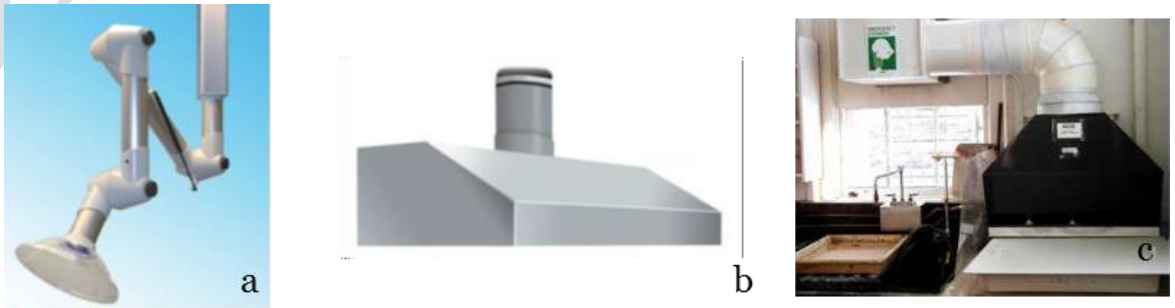


Figure 4.3 Elephant trunk (a), canopy (b), slot and plenum (c)

4.2.2.2. *Canopy*

Canopy **(Figure 4.3.b)** is useful for hot operations or to exhaust materials that are lighter than air.

4.2.2.3. *Slot and Plenum*

Slot and plenum **(Figure 4.3.c)** are useful for heavy vapors or particulates because they pull the contaminant backwards, away from the user, into the plenum before exhausting it up and out.

4.2.3. *Glove Boxes*

Glove boxes (or gloveboxes) are sealed container design to protect the user, the process or both. They usually includes at least one pair of gloves attached to the container. The user handles the materials inside using the gloves. Typically, a glove box has an antechamber that is used to materials transfer.

4.2.4. *Safety Shields*

Safety shields, such as the sliding sash of a fume hood, are designed to protect the personnel from sudden spattering or explosion release of **highly concentrated acids, bases, oxidizers or reducing agents**

4.2.5. *Ventilated Storage Cabinets*

These are cabinets **(Figure 4.4)** which are fitted with forced ventilation. They may be free-standing with their own extract system, or may be situated beneath a fume cupboard and attached to its duct. They are designed to safely store chemicals that give off noxious fumes and smells. These fumes are sucked away by the forced ventilation.

Ventilation of chemical storage cabinets may only be accomplished with prior approval by LSS. For appropriate storage requirements of a particular chemical, please see **ChemWatch.**

Figure 4.4 Cabinets suitable for acid-base or solids chemicals storage (left) and cabinet suitable for combustible chemical storage (right)

4.2.6. Compressed gas cabinets

Highly toxic or odorous gases should be used and stored in gas cabinets **(Figure 4.5).** In the event of a leak or rupture, a gas cabinet will prevent the **gas** from contaminating the laboratory.

Figure 4.5 Compressed gas cabinet

College of Energy and Environmental Sciences

Department of Environmental Sciences

Laboratory Safety

Dr. Zaid .M. Joodi

5th ,and6th lectures 4th Stage

5. BIOLOGICAL SAFETY

5.1.BIOLOGICAL SAFETY LEVELS

A biosafety level is the level of the biocontainment precautions required to isolate dangerous biological agents in an enclosed facility. The levels of containment range from the lowest biosafety level 1 to the highest at level 4. In the United States, the Centers for Disease Control and Prevention (CDC) have specified these levels. In the European Union, the same biosafety levels are defined in a directive. Sabanci University is following the same directive in accordance with Turkish biological safety regulation.

The term "containment" is used in describing safe methods for managing infectious materials in the laboratory environment where they are being handled or maintained. The purpose of containment is to reduce or eliminate exposure of laboratory users, other people, and the outside environment to potentially hazardous agents.

Biocontainment can be classified by the relative danger to the surrounding environment as biological safety levels (BSL). As of 2006, there are four safety levels. These are called BSL1 through BSL4.

5.1.1 Biosafety Level 1

This level is suitable for work involving well-characterized agents not known to consistently cause disease in healthy adult humans, and of minimal potential hazard to laboratory users and the environment (CDC, 1997). It includes several kinds of bacteria and viruses including canine hepatitis, Escherichia coli, varicella (chicken pox), as well as some cell cultures and non-infectious bacteria. At this level precautions against the biohazardous materials in question are minimal, most likely involving gloves and some sort of facial protection. The laboratory is not necessarily separated from the general traffic patterns in the building. Work is generally conducted on open benchtops using standard microbiological practices. Usually, contaminated materials are left in open (but separately indicated) rubbish receptacles. Decontamination procedures for this level are similar in most respects to modern precautions against everyday microorganisms (i.e., washing one's hands with anti-bacterial soap, washing all exposed surfaces of the lab with disinfectants, etc.). In a lab environment all materials used for cell and/or bacteria cultures are

decontaminated via autoclave. Laboratory users have specific training in the rocedures conducted in the laboratory and are supervised by a scientist with general training in microbiology or a related science.

5.1.2 Biosafety Level 2

This level is similar to Biosafety Level 1 and is suitable for work involving agents of moderate potential hazard to personnel and the environment. It includes various bacteria and viruses that cause only mild disease to humans, or are difficult to contract via aerosol in a lab setting, such as C. diff, hepatitis A, B, and C, influenza A, Lyme disease, dengue fever, Salmonella, mumps, Bacillus subtilis, measles, HIV, scrapie, MRSA, VRSA, etc. Genetically modified organisms have also been classified as level 2 organisms, even if they pose no direct threat to humans. This designation is used to limit the release of modified organisms into the environment. Approval by the FDA is required to release these organisms. An example is genetically modified food crops. BSL-2 differs from BSL-1 in that:

- Laboratory users have specific training in handling pathogenic agents and are directed by scientists with advanced training;
- Access to the laboratory is limited when work is being conducted;
- Extreme precautions are taken with contaminated sharp items; and
- Certain procedures in which infectious aerosols or splashes may be created are conducted in biological safety cabinets or other physical containment equipment.

5.1.3 Biosafety Level 3

This level is applicable to clinical, diagnostic, teaching, research, or production facilities in which work is done with indigenous or exotic agents which may cause serious or potentially lethal disease after inhalation. It includes various bacteria and viruses that can cause severe to fatal disease in humans, but for which vaccines or other treatment exist, such as Mycobacterium tuberculosis, Bacillus anthracis, West Nile virus, Venezuelan equine encephalitis virus, Eastern equine encephalitis virus, Hendra virus, SARS corona virus, Salmonella typhi, Coxiella burnetii, Rift Valley fever virus, Rickettsia rickettsia, and yellow fever virus.

Laboratory users have specific training in handling pathogenic and potentially lethal agents, and are supervised by competent scientists who are experienced in working

with these agents. This is considered a neutral or warm zone.

All procedures involving the manipulation of infectious materials are conducted within biological safety cabinets or other physical containment devices, or by personnel wearing appropriate personal protective clothing and equipment. The laboratory has special engineering and design features.

It is recognized, however, that some existing facilities may not have all the facility features recommended for Biosafety Level 3 (*i.e.*, double-door access zone and sealed penetrations). In this circumstance, an acceptable level of safety for the conduct of routine procedures, (e.g., diagnostic procedures involving the propagation of an agent for identification, typing, susceptibility testing, etc.), may be achieved in a biosafety level 2 facility, providing:

- The filtered exhaust air from the laboratory room is discharged to the outdoors,
- The ventilation to the laboratory is balanced to provide directional airflow into the room,
- Access to the laboratory is restricted when work is in progress, and
- The recommended standard microbiological practices, special practices, and safety equipment for biosafety level 3 are rigorously followed.

5.1.4 Biosafety Level 4

This level is required for work with dangerous and exotic agents that pose a high individual risk of aerosol-transmitted laboratory infections, agents which cause severe to fatal disease in humans for which vaccines or other treatments are not available, such as Bolivian and Argentine haemorrhagic fevers, Marburg virus, Ebola virus, Lassa fever, Crimean-Congo haemorrhagic fever, and other various haemorrhagic diseases. When dealing with biological hazards at this level, the use of a Hazmat suit and a self-contained oxygen supply is mandatory. The entrance and exit of a Level 4 biolab will contain multiple showers, a vacuum room, an ultraviolet light room, and other safety precautions designed to destroy all traces of the biohazard. Multiple airlocks are employed and are electronically secured to prevent both doors opening at the same time. All air and water service going to and coming from a biosafety level 4 lab will undergo similar decontamination procedures to eliminate the possibility of an accidental release.

Agents with a close or identical antigenic relationship to Biosafety Level 4 agents are handled at this level until sufficient data is obtained either to confirm continued work at this level, or to work with them at a lower level.

Laboratory users have specific and thorough training in handling extremely hazardous infectious agents and they understand the primary and secondary containment functions of the standard and special practices, the containment equipment, and the laboratory design characteristics. They are supervised by qualified scientists who are trained and experienced in working with these agents. Access to the laboratory is strictly controlled by the laboratory director.

The facility is either in a separate building or in a controlled area within a building, which is completely isolated from all other areas of the building. A specific facility operations manual is prepared or adopted. Building protocols for preventing contamination often use negatively pressurized facilities, which, if compromised, would severely inhibit the containment of an outbreak of aerosol pathogens.

Within work areas of the facility, all activities are confined to Class III biological safety cabinets, or Class II biological safety cabinets used with one-piece positive pressure personnel suits ventilated by a life support system. The Biosafety Level 4 laboratory has special engineering and design features to prevent microorganisms from being disseminated into the environment. The laboratory is kept at negative air pressure, so that air flows into the room if the barrier is penetrated or breached. Furthermore, an airlock is used during personnel entry and exit. **Table 5.1.** summarizes the biosafety levels.

Table 5.1 Biosafety levels

Biosafety Level	***1***	***2***	***3***	***4***
Infectious Agents	Unlikely to cause disease in healthy workers or animals Low individual and community	Can cause human or animal disease but unlikely to be a serious hazard Moderate individual risk, limited community risk Effective treatme	Cause serious human or animal disease but not ordinarily spread by casual contact High individual risk, low community risk	Cause very serious human or animal disease, often untreatable and transmitted High individual risk, high community risk

	risk	nts available		
Examples of infectious agents in this risk level		E. coli, California encephalitis viruses, many influenza viruses	Anthrax, Q fever, tuberculosis, Hantaviruses, human immuno-deficiency viruses	Ebola viruses, Herpes B virus (Monkey virus), foot and mouth disease
Facilities	Standard well-designed experimental animal and laboratory facilities	Level 1 plus: Separate laboratory, room surfaces impervious and readily cleaned, biohazard sign	Level 2 plus: Controlled access double door entry and body shower, air pressure must be negative at all times, no recirculation, HEPA filtration, backup power	Specialized, secure, completely self-contained unit with specialized ventilation, fully monitored; air lock entry and exit,
Safety Equipment	Handwashing facilities, laboratory coats	Level 1 plus: autoclave, HEPA filtered class I or II biological safety cabinet, personal	Level 2 plus: Autoclave, HEPA filtered class II biological safety cabinet, personal protective equipment to include solid	Class III biological safety cabinets, positive pressure ventilated suits

		protective equipment	front laboratory clothing, head covers, dedicated footwear, and gloves, appropriate respiratory protection	
Procedures	Basic safe laboratory practices	Use of personal protective equipment laboratory coat worn only in the laboratory, gloves, decontaminati on	Users fully trained, written protocols; showers, wastes disposed of as contaminated, use of biological safety cabinets, personal protective devices	Access only to certified staff, rigorous sterilization / decontamination procedures

6.1. Risk Assessment

For typical laboratory operations, biosafety level classifications are convenient. Based on laboratory specific conditions, the Responsible Faculty Member or LS/LSS is in charge of implementing more (or less) strict practices. Risk assessment decisions count for the following:

- Pathogenicity - the ability of an organism to cause disease.
- Virulence - the severity of disease.
- Transmission route - parenteral, ingestion, mucous membrane exposure, or inhalation. Organisms such as M. tuberculosis require more strict control than organisms that are transmitted via direct contact, e.g., HBV.
- Agent stability - survival in environment or otherwise prolonged viability (spore formation).
- Infectious dose - the dose required to cause infection in humans or animals (ID 50 refers to the dose needed to infect 50 % of the exposed population).
- Antibiotic resistance.
- The use of recombinant DNA - any of the above risk factors and modifications

should be taken into consideration.

All of the above factors are inherent to a particular microbe; external factors to be considered in a risk assessment include:

- Titer/volume of material used - titer may increase several orders of magnitude compared to levels in clinical samples, upon culturing.
- Availability of effective treatment or vaccine.
- Nature of activities - e.g., potential for splashes, volume used, skills and training level of the users.
- Health status of the lab user - such as immune status, pregnancy, vaccination status.

College of Energy and Environmental Sciences

Department of Environmental Sciences

Laboratory Safety

Dr. Zaid .M. Joodi

7^{th} ,8^{th} ,9^{th} &10^{nd} lectures

4^{th} Stage

7.1. TISSUE CULTURES AND CELL LINES

Cell lines obtained from commercial sources may become contaminated with adventitious agents while used in the laboratory. The extent of screening varies among providers and while most test for bacteria, mycoplasma, and fungi, they do not routinely include testing for viruses other than those categorized as "Blood borne Pathogens".

Cell cultures known to contain an infectious agent or oncogenic virus should be manipulated at the Biosafety Level appropriate for the agent, usually BSL-2.

For activities with materials not known to contain infectious agents, the following hazard classification applies:

BSL-1 is appropriate for well-established lines of cells of sub-primate origin if they do not harbour a primate virus and are free of bacteria, fungi, and mycoplasma. However, working with these materials at BSL-2 is recommended because of the additional degree of protection from contamination provided by BSL-2 practices, particularly the use of a Biological Safety Cabinet.

BSL-2 is appropriate for activities with: all primate cell lines, even well established ones, all cells derived from primate lymphoid or tumor tissues; all primate tissue; all human clinical material; cultured cells new to the laboratory until proven contaminant-free; and, cells exposed to or transformed by a primate oncogenic virus.

These activities and the use of any cells purposely infected with or suspected of harbouring agents defined as bloodborne pathogens are covered by the Bloodborne Pathogens Standard (in accordance with CDC). Laboratories using human cell strains (non-transformed cells) propagated from primary explants must also comply with the Standard because they are considered "unfixed human tissue" which is covered by the regulation.

7.2. SAFETY DATA SHEETS FOR INFECTIOUS SUBSTANCES

Safety data sheets (SDS), for chemical products have been available to lab users for many years. However because many laboratory users, whether in research, public health, teaching, etc., are exposed to not only chemicals but infectious substances as well, there was a large gap in the readily available safety literature for lab members. These SDS are produced for personnel working in the life sciences as quick safety reference material relating to infectious micro-organisms. Sabanci University employs **ChemWatch** software for SDS reference documents generation.

The SDS are organized to contain health hazard information such as infectious dose, viability (including decontamination), medical information, laboratory hazard, recommended precautions, handling information and spill procedures. The intent of these documents is to provide a safety resource for laboratory users working with these infectious substances. Because these users are usually working in a scientific setting and are potentially exposed to much higher concentrations of these human pathogens than the general public, the terminology in these SDS is technical and detailed, containing information that is relevant specifically to the laboratory setting. It is hoped along with good laboratory practices, these SDS will help provide a safer, healthier environment for everyone working with infectious substances.

7.3. ENGINEERING CONTROLS AND LABORATORY EQUIPMENT

Engineering controls are devices and equipment that isolate the possible hazards and compensate for user errors. They function with a minimum of user input.

In addition to electrical and mechanical considerations, laboratory equipment may end up with hazards related to the materials used in them. Therefore, before using some equipment, training is required for operational aspects.

Be sure that manuals are readily accessible and when in doubt, contact a customer service representative. Do-it-yourself fixes are not only dangerous but may invalidate warranties. Responsible Faculty Member or LS/LSS are responsible for ensuring that new users are familiar with the safe operation of equipment.

There also may be specific requirements for moving sophisticated machinery in which case a customer service official should be contacted or the users' manual carefully reviewed.

The biosafety-relevant engineering controls and laboratory equipment are described as follows:

7.3.1. Biological Safety Cabinets (BSCs)

Biosafety cabinets are the essential engineering control for the minimization of exposure to potentially infectious materials. For protecting researchers and the environment from aerosolized microorganisms, BSCs consolidate directional air flow and high efficiency particulate air (HEPA) filters. To prevent the contaminants entering the laboratory, air enters the cabinet through the face (where the user sits) and the air released from the cabinet first passes through a HEPA filter, evacuating 99.97% of particles with an aerodynamic diameter of 0.3 microns; smaller or larger particles are removed with more prominent productivity. BSCs should be used for **all open manipulation of organisms requiring BSL-3 containment and activities with a BSL-2 organism having potential for splashes or aerosol generation**.

7.4.1.1. Class I BSC

Room air enters at face, circulates within the work space, and exits through the HEPA filter after passing through the rear plenum. These type of cabinets protect the user and the environment, but they do not protect research materials from environmental contamination.

7.4.1.2. Class II, type A1 BSC

Room air draws through the supply grille at the front of the work area and entering the rear plenum, passes through a fan. Portions of air stream pass through an exhaust filter or supply filter. Only HEPA-filtered air contacts the work area, providing protection from environmental contamination of research materials.

Please note that, Class I and Class II biosafety cabinets exhaust filtered air back into the laboratory. Gases or vapors, volatile, toxic chemicals are not captured by HEPA filters so they must not be used in these BSCs. Limited quantities of these materials may be used in Class II, type B cabinets, which discharge into building exhaust systems.

7.4.1.3. Class III BSC

Often referred to as “glove boxes”, these are totally enclosed, gas-tight cabinets designed for work with the highest risk pathogens. Before being discharged through ventilation systems, exhaust from Class III cabinets is filtered.

Some laboratories have clean air benches which can be confused with BSCs because of their physical similarities. They are not safety devices and should never be used for handling infectious materials. Clean air benches draw air through a filter and direct a filtered airstream. They are designed for handling sterile materials or when a dust-free environment is needed.

7.4.1.4. Procedures for effective use of BSCs

Appropriate user protection and contamination prevention provided by a BSC is directly related to the activities of the operator.

Cabinets must be certified under the following conditions:

- Annually
- Following relocation (including within-room). BSC on castors may be moved carefully without subsequent recertification.
- Following HEPA filter change
- Following service that may have affected containment ability.

- Semi-annual certification is recommended when cabinets are used for work with airborne-transmitted organisms or other high risk agents, e.g. M. tuberculosis.
- If the airflow, indicated by magnehelic gauges fall out of an established range.

To maintain proper directional airflow, do not block the front air intake or the rear exhaust grille and minimize the amount of material kept inside the cabinet.

- HEPA filters may be harmed and the protective airflow pattern may be disrupted by heat from a Bunsen burner. The utilization of disposable immunizing supplies joined with the sterile climate of the BSC, should eliminate the need for heat decontamination throughout the procedure.
- There should be 10-15 cm working distance from the front of the cabinet. Working should be done over the tray and not over the grille. Rapid arm movements that can disrupt airflow should be avoided.
- In order to minimize arm movement in and out of the cabinet, all needed materials should be placed in BSC at the start of procedures and arranged so that 'dirty' items do not pass over 'clean' ones. Clean cultures (left) can be inoculated (center); contaminated pipettes can be discarded in the shallow pan and other contaminated materials
- Cabinet fan should be allowed to run 5 minutes prior to and at the completion of work and the

interior should be wiped with 70% ethanol before and after work.

- BSCs should be located in low-traffic areas away from air supply grilles and doorways; drafts may disrupt protective air flow.
- Many BSCs are equipped with UV lights. UV lights should be turned off when the cabinet is in use and wiped with an alcohol-moistened cloth weekly; a dust covered bulb is ineffective. Bulbs must be disposed via **hazardous waste** protocol.
- When working in a BSC, the door should be closed, particularly if it is close to a laboratory door.
- Most BSCs have a removable work surface tray and front grille, and the space beneath it requires regular cleaning to avoid contamination problems. A schedule for regular removal of the work surface tray and disinfection of the space beneath with 10% bleach followed by 70% ethanol is recommended.

7.3.2. Vacuum Line HEPA Filters

Vacuum lines require periodic maintenance and it is crucial to ensure that exposures to research materials are prevented. All vacuum lines, both inside BSCs and on benchtops must be protected with a HEPA filter and a disinfectant-filled collection flask.

7.3.3. Sharps Containers and Safe Needle Devices

7.4.3.1. Sharps containers

*Needles, razor and scalpel blades and similar items are discarded through **Contaminated Waste** procedure, and must be kept in sharps containers.*

Improperly disposed sharp items or sharps that were left “lying around” may cause cuts; so a sharps container should be kept as close as possible to where these items are used, if possible within arm's reach.

- Glass items (pipettes, test tubes) should be substituted whenever possible by plastic ones. The use of sharp objects should be limited if there is an alternative way.
- Blunt needles, pipettes, or canulas should be used to aspirate fluids instead of hypodermic needles; and if possible plastic should be substituted for glass.
- Needle-locking units or units should be used only in which the needle is an integral part of the syringe.
- All needles should properly be disposed in a "sharps" container immediately after use.
- Unused needles should be disposed in sharps containers.
- Needles should never be recapped, sheared, broken, or bended under any circumstances. Air and bubbles should be expelled into a disinfectant-moistened pad.

7.4.3.2. Safe needle devices

Safe needle devices include 'needleless systems' and sharps which have automatic protection features. These devices eliminate the exposure to and minimize the risk of cuts. They are generally applicable to clinical settings but must be incorporated whenever there is the risk of exposure to materials

containing recombinant DNA, human blood, body fluids, cells, unfixed tissue or any other material covered by **Bloodborne Pathogens Standard.**

7.3.4. Centrifuge Safety

Centrifuge accidents may release large volumes of infectious, aerosolized material.

- Rotor usage logs and decommission rotors as per manufacturers’ recommendations must be corporated.
- Rotors, particularly the chambers must be inspected for corrosion and pitting.
- “Safety cups” or covers (gasketted containers into which tubes are placed during centrifugation) must be used. If a tube breaks, the material will be contained. These safety devices can be obtained from the manufacturer.
- If a safety cup is unavailable, the rotor cover or chamber lid must tightly be closed and an uncovered rotor may never be used.
- Tubes must be filled and rotors or safety cups inside a BSC must be loaded/unloaded for infectious materials or materials containing recombinant DNA.
- In case of a tube breakage during centrifugation:
    - Aerosols must be allowed to settle for 15 minutes before opening the chamber.
    - Personal protective equipment must be used as described in **Spill Procedures.**

- A squeeze bottle must be used to carefully apply disinfectant solution to contaminated surface.
- 20 minutes contact time must be allowed, buckets and rotors must be removed to nearest BSC, aspirate residual disinfectant must be aspirated, and all the surfaces must be wiped with clean water.
- Debris must be placed in sharps containers or red bags.
- Manufacturers' instruction must be followed for selection of disinfectants for use on rotors and buckets. These items are usually corrosion-sensitive.

7.3.5. Water Baths

In case of water bath contamination by organisms incubated in them or through amplification of water/airborne organisms, it is recommended to use iodine-based or **phenolic** disinfectants for intermediate temperature baths. It is also effective to use 1/1,000 diluted household bleach. However, it may corrode water bath components. Also placing a few pennies (copper) in the bath will inhibit microbial growth. Sodium azide must never be used; it is highly toxic, and may result in the formation of **explosive** metal azides. For the recommended disinfectant, the manufacturer should be consulted. Water baths should not be left overnight or when they will be unattended for an extended period of time.

7.3.6. Cryostats

Cryostat decontamination must be regularly done with a proper tuberculocidal hospital disinfectant (see in 7.5. **Decontamination**). Tissue sections and trimmings should be treated as highly infectious. Never clear debris from a blade with your hand; always use a proper brush or other mechanical means to prevent contact with the blade. When replacing blades use protective gloves and forceps or tongs to handle the blades. Pre-soak blades in a disinfectant solution before cleaning (removal of debris). This will decrease the population of viable microorganisms.

7.3.7. Mixers, Sonicators, and Blenders

Mixers, sonicators, and blenders are source of vast amount of aerosols. There are suitable models available to contain aerosols. Afore mentioned devices must be run within a BSC with a disinfectant-moistened towel placed over the top. Let the aerosols settle, then open the device. Avoid using glass bowls. Sonication can be securely accomplished by placing a firmly capped specimen tube in a beaker of water and putting the probe in the water, not in the tube.

7.3.8. Lyophilizers

A dry solid which is very easily dispersed is produced by lyophilizers. Fitting with a HEPA filter or venting to a BSC is advised when it used for drying suspensions of infectious substances. Lyophilized solids must be opened only in a BSC; put a disinfectant-moistened pad over the scored line, then open the ampoule. Hence, disinfect chamber area and any material collected in the vapor trap.

7.4. DECONTAMINATION

An activity that decreases the microbial load to a level deemed proper to avoid contamination or infection is decontamination. The suitability of a decontamination procedure depends on occasions. For example, surgical instruments must be sterile. However, this level of microbial disinfection is pointless for environmental areas, such as walls and floors.

The application of a chemical to living tissue to prevent infection refers as antisepsis. Example substances are iodine compounds and hand washing antimicrobial soaps.

7.4.1. Sterilization

Sterilization refers to the disinfection of all microbial life, including bacterial endospores.

7.4.2. Autoclaves

The most efficient and reliable method of sterilization in laboratory is offered by autoclaves. Critical process factors are exposure, temperature, time. Also ensuring that materials are packaged to allow the steam to penetrate throughout the load is another crucial parameter. Size of the load and the packing density of the chamber affects the sterilization time. Usual laboratory autoclaves function at 121 °C and 15 psi. All users must review the operating manual periodically. Instructions should be prominently posted. When removing processed material, heat resistant gloves and face protection must be used. Slowly crack the door and wait a few minutes before fully opening it.

For dry loads, addition of 250-500 mL of water to the load pan in order to aid steam generation is

necessary. Do not tightly cap bottles and test tubes. Autoclave bags must be closed loosely to allow steam to penetrate.

Autoclave tape is not a fail-safe indicator of sterilization; it blackens after only brief exposure to a temperature of 121 °C.

Some autoclave tapes contain lead which makes it necessary to dispose of these tapes as **Hazardous Waste**. For properly eliminating this hazardous waste stream, laboratories must use lead-free autoclave tape.

7.4.3. Dry Heat

Dry heat is used for materials (some glassware, instruments, and anhydrous materials) that are sensitive to moisture or the corrosion it may cause. Consult the manufacturers of such items for recommendations for appropriate sterilization procedures. Dry heat requires higher temperatures and a longer exposure times than autoclaving. Dry heat for 2-4 hours at 160 °C is needed to sterilize a load requiring 30 minutes at 121 °C in an autoclave. This method may also be validated by using spore vials; see **Autoclave** section (above).

7.4.4. Chemical Sterilization

Chemical sterilization is mainly used for heat-sensitive patient-care instruments which enter body cavities or normally sterile areas. This process necessitates prolonged contact times with relatively high concentrated solutions. As a result, prior to dilution, these toxic products must be treated as **hazardous chemicals.** Cautiously follow manufacturers' directions regarding dilution, contact time and personal protective equipment. Some sterilants require specific ventilation systems in order to remove hazardous gases and vapors.

7.4.5. Disinfection

Elimination of virtually all pathogenic microorganisms on inanimate objects with the exception of large numbers of bacterial endospores is called disinfection.

Disinfection should be established if hazardous organisms are destroyed. Microorganisms can be grouped according to decreasing resistance to disinfectants as follows: bacterial endospores (*B. subtilis, clostridium spp*); Mycobacteria; nonlipid or small viruses (poliovirus, rhinovirus); fungi; vegetative bacteria; and lipid or medium sized virus (herpes simplex, HIV, HBV).

Table 7.2. offers a framework for the selection of the proper disinfectant.

When using any disinfectant:

- Label instructions must be followed for dilution and time needed for desired level of disinfection must be contacted.
- Disinfectants that require pre-use dilution must be treated as **hazardous chemicals** while mixing.
- Wear a proper lab coat, the correct type of chemical-resistant glove, and fit goggles (not glasses).
- Clean contaminated surfaces that may have become contaminated at the end of the task.
- Choose the disinfectant with the lowest possible toxicity.

Considerations for selecting and using disinfectants:

- Rough surfaces require a longer contact time than smooth ones.
- Surface compatibility-bleach will corrode many metals, after use rinse it with water. Based on their composition, instruments vary in their ability to withstand disinfectants.
- Organic compounds will inactivate some disinfectants; a second treatment may be necessary once visible contamination (and hence, most organic debris) has been removed. The removal of visible 'soil' is the most critical factor in assuring effective decontamination.
- Resistance of microorganisms, e.g. bacterial endospore vs. vegetative bacteria.
- Number of microorganisms present, overnight culture vs. a recently inoculated one.

The **Bloodborne Pathogens Standard** requires that products labelled "tuberculocidal hospital disinfectant" be used on surfaces and equipment when the Standard is in force. Household bleach, usually at a 1/10 dilution, also satisfies this requirement and may be used in these cases. Bleach solutions lose potency over time and should be prepared fresh daily. **Table 7.2** summarizes the disinfectant activities:

Table 7.2 Summary of disinfectant activities							
Disinfectant	**Disinfection Level**	**1***	**2***	**3***	**4***	**5***	**Comments**
Alcohols (ethyl and isopropyl) 60-85%	intermediate	+	+	-	+/-	+	Not sporicidal; evaporates quickly so that adequate contact time may not be achieved, high concentrations of organic matter diminish effectiveness; flammable.
Phenolics (0.4%-5%)	intermediate	+	+	+/-	+	+	Not sporicidal; phenol penetrates latex gloves; eye/skin irritant; remains active upon contact with organic soil; may leave residue.
Glutaraldehyde (2-5%)	High	+	+	+	+	+	Used to sterilize surgical instruments that cannot be autoclaved; strong odor; sensitizer; use with adequate ventilation. Not for use on environmental surfaces.
Quaternary Ammonium (0.5-1.5%)	Low	+	+	-	-	+/-	May be ineffective against Pseudomonas and other gram – bacteria; recommendation limited to environmental sanitation (floors, walls). Low odor, irritation.
Iodophors (30-1,000 ppm iodine)	intermediate	+	+	+	+/-	+/-	Inactivated by organic matter.
Chlorine (100-1,000 ppm)	intermediate	+	+	+	+/-	+	Not sporicidal; inactivated by organic matter; fresh solutions of hypochlorite should be prepared daily; corrosive; irritating to eyes and skin.

** 1. Bacteria; 2. Lipophilic Viruses; 3. Hydrophilic Viruses; 4. Mycobacterium Tuberculosis; 5. Fungi*
Adopted from Columbia University, Medical Center.

7.4.6. Using Bleach as a Disinfectant

As a strong oxidizing agent, the sodium hypochlorite in household bleach is an effective disinfectant for the known and potential infectious materials. However, as sodium hypochlorite breaks down into salt and water, it is recommended that the solution is made fresh daily. When bleach and water are mixed together, 1:10, to create a cleaning or disinfecting solution, the solution rapidly begins to lose needed disinfecting properties.

Bleach stock must be stored in an opaque plastic bottle at room temperature. Initial hypochlorite concentration is affected by the rate of degradation, the volume remaining and the ambient temperature. A good practice is to mark the bottle with the receive date, and replace bleach that was received more than 6 months prior. Colorimetric test strips for hypochlorite concentration offers an useful monitoring means.

All bleach brands are not manufactured to the same potency. Depending on manufacturer, the potency of commercial bleach is between 3.25 and 6.15% hypochlorite.

Proper gloves must be worn while handling bleach, because it can be corrosive on some surfaces, including steel. Bleach residue on non-porous surfaces must be wiped off with 70% ethanol or water. As ammonia and bleach can react to produce a highly toxic product, bleach should not be used in conjunction with other household cleaning products that contain ammonia. Pre-filled spray bottles that contain a 1:10 mixture are appropriate for using in the lab. Aspiration of tissue culture media into a collection flask, under vacuum, is one of the most commonly performed laboratory procedures. SU Policy requires that such media may be decontaminated prior to disposal in the municipal sewer system (**Waste Management**). Following these instructions guaranties effective decontamination.

Bleach must be added before aspiration, and undiluted bleach must be added to fill 10% of the final volume of the collection flask. Bleach is an active decontaminant. Also, its strong oxidizing properties will turn the phenol red indicator in tissue culture media from pink to yellow/clear. Aspiration flasks

containing pink liquid is a sign of insufficient bleach concentration. So they should be topped off with fresh bleach until a yellow/clear colour is obtained. The collection flasks must be emptied when they are 3/4 full.

7.5. GEL ROOM, DARK ROOM, RADIOISOTOPE ROOM AND COLD ROOM SAFETY

7.5.1. Gel Room Safety

Electrophoresis is a commonly used laboratory technique which uses electrical energy to separate molecules such as proteins or nucleic acids by their size, structure, and electrical charge. Electrophoresis work poses potential **electrical**, **chemical** and thermal safety hazards.

Electrophoresis equipment can pose significant **electrical** hazards in the laboratory. Typical electrophoresis units operating at 100 Volts can provide a lethal shock of 25 milliamps. Take the following precautions when working with electrophoresis equipment:

Power Supplies:

- Ensure all switches and indicators are in proper working condition and that power cords and leads are undamaged and properly insulated.
- Label equipment with the warning: "Danger Electrical Hazard."
- Connect equipment to outlets with ground fault circuit interrupters (GFCIs).
- Use power supplies with safety features that detect issues with the electrical circuit (e.g., no-load, overload, sudden load changes, short circuits, etc.).

Connecting Leads:

- Turn off main power supply before connecting or disconnecting electrical leads.
- With dry gloved hands, connect one lead at a time using one hand only.
- Be sure that leads/banana plugs are fully seated.

Using Equipment:

- Don't run equipment unattended.
- Keep equipment clear of unintentional grounding points and conductors (e.g., sinks or other water sources, metal plates, jewellery, aluminium foil, pipes or other electrical/metal equipment).
- Gel chamber must have a lid or cover with safety interlocks to prevent accidental contact with energized electrodes or buffer solutions.
- Gel chamber exterior must be dry with no spilled solutions. Check the chamber for leaks.
- Switch off all power supplies and unplug the leads before opening the gel chamber lid or reaching inside the gel chamber. Do not rely on safety interlocks.

Users may be exposed to thermal hazards when heating agarose solutions.

Ultraviolet (UV) light boxes and handheld lamps are often used in visualizing ethidium bromide gels and pose potential exposures to UV radiation.

Hazardous chemicals commonly used in conjunction with electrophoresis work include:

- Ethidium bromide – mutagen, irritant
- Acrylamide – carcinogen, neurotoxin, irritant
- **Phenol** – corrosive, toxic
- Chloroform – suspect carcinogen, toxic

General Work Practice:

- Read and follow manufacturer's instructions for electrophoresis equipment.
- Instructions should include operating procedures written by the manufacturer and laboratory, as well as the associated hazards, the correct personal protective equipment (e.g., lab coats, gloves, and eye protection), and applicable emergency procedures.
- Use double gloves while working in the gel room, remove the contaminated gloves safely and dispose of before leaving the room.
- Locations where ethidium bromide is used or stored must be identified with "Mutagenic" marked stickers. Do not remove the hazard out of room.
- Only trained and qualified users are permitted to operate gel electrophoresis equipment. Responsible Faculty Member or LS are responsible for ensuring that all users are trained to use the equipment in a safe manner. Training should include special hazards and safety precautions.
- Measure, mix, and handle hazardous powdered chemicals or gel prep mixtures with hazardous components (e.g., acrylamide monomer, **phenol**, ammonium persulfate, and formaldehyde)

in the fume hood.
- Purchase pre-made gels or pre-mixed acrylamide and ethidium bromide solutions instead of making your own.
- Consider using ethidium bromide substitutes.
- Exercise caution when using a microwave to melt agarose solutions; don't use sealed containers, and beware of superheated liquids that may suddenly and unexpectedly boil. Let hot agarose solutions cool to 50-60 °C before adding ethidium bromide or pouring into trays. Wear insulated gloves and point the flask opening away from you.
- During normal use, small spills may occur and residues may build up on equipment and other laboratory surfaces. A solution of soap and water is recommended for cleaning small spills and removing residues on equipment and laboratory surfaces. For more information see **Emergency Procedures**.

Ethidium Bromide waste in concentrated or solid form is collected as hazardous waste and should not be flushed down the drain or disposed of in the trash. Gels containing ethidium bromide can be easily de-stained in the laboratory by simply placing the gels in a DI-water bath for 15 minutes and gently agitating or 15 min treatment under UV light. This eliminates the need to collect the gels as a hazardous waste. For information on disposal of other hazardous materials please see **Waste Management** section.

7.5.2. Dark Room and Radioisotope Room

*Radioactive labelling is conducted in SU and is restricted to Radioisotope room which is interconnected with the Dark room (Room FENS 2078). All potential hazards must be taken into account while conducting experiments in this facility and access is only granted upon corresponding **training**.*

The following describes general guidelines associated with work in the facility, for further information please see **Radiation Safety** section.

7.6.2.1. Dark room

It is of high importance to keep the dark room clean at all times. All chemicals shall be stored and labelled appropriately. Secondary containers should be placed under all chemicals in storage.

The darkroom is a low light and even no light working environment. Be sure that:

- There are no obstacles left around that could be tripped over.
- Check the labels of the chemicals before turning off the main white lights.
- Make sure equipment that you need is at hand.

Use necessary **PPE**:

- Splash proof safety goggles and appropriate gloves are to be used at all times.
- Dispose of the contaminated gloves prior to leaving the work area.
- As in any chemical area, clothing in the darkroom should offer protection from splashes and spills. Clothing should be easily removable in case of accident.

Dispose of all chemicals through **hazardous waste** procedure. Take care of any spills immediately (see **Emergency Procedures** section)

Under no circumstance block the radioisotope room entrance.

7.6.2.2. Radioisotope room

Radioactive material at SU, is mainly used for biomedical research in the radioisotope room and in the Physics programme. Such research could be interrupted or stopped completely without the use of radioactive materials.

SU is devoted to ensure that the use of radioactive materials is carried out in a safe manner for employees, students, the public and the environment.

In Turkey, the possession and the use of radioactive materials is governed by the Radiation Safety Rules and Regulations administered by the Turkish Atomic Energy Agency (TAEK). SU holds a consolidated license covering the possession use, storage, import and export of radioactive materials, and a waste license covering the disposal of radioactive materials.

General Safety Practices

In the use of radioactive materials for teaching or research, consideration must also be given to other physical, chemical and biological hazards which may arise during the procedure. Care should be taken to ensure that the safety requirements necessary for radioisotope use do not compromise the safety requirements for the use of other hazardous agents.

Work Area Safety

- All **radioisotopes** must be kept locked. Only authorized people can work with them.
- Work must be limited to an area in laboratory with minimal traffic.
- All radioisotope usage areas must be labelled properly with radiation warning labels.
- **Radioactive waste** keeping should not be performed without adequate shielding and containment, since the users working in this area may be exposed to radiation.
- Disposable absorbent materials must be used to cover work area, and in the case of a spillage this area must immediately be evacuated.
- Radioisotope work areas must be obstacle free. For example, laboratory records and books should be kept away from possible contamination.
- If there is a possibility of volatilization of the radioactive material, working under fume hood is a necessity. A dry-box or transfer-hood must be used working with dusty radioactive materials. In addition, gloves, safety glasses and, if necessary, face masks or respirators, must be worn.
- Fume hoods must not be used for storage of materials which may disrupt the air flow.
- A radiation dosimeter (whole body) must be worn at all times according to specified radioisotope permit. Also wearing an extremity dosimeter (ring badge) in case of a specific radioisotope is a necessity.
- Within seven days of the usage of radioisotopes, monitoring and contamination control checks must be carried out.
- Eating, drinking, use of cosmetics or other material in contact with the skin is strictly forbidden in the laboratory. Food containers must not be stored in a radioisotope laboratory or in a refrigerator used to store radioisotopes.
- Before working with radioactive material, any wound in the skin should be properly protected by a waterproof covering.
- All equipment used during a radioisotope procedure must be labelled with appropriate radiation warning labels. If possible, this equipment must be kept separate from general laboratory area. If an item is decontaminated, remove the warning labels.

- Radioactive solutions must be labelled with radiation warning tape including relevant information such as the activity and its radioisotope. All containers contaminated with radioactive materials must be labelled, covered and stored properly.
- Designate proper glassware for radioisotope work. Wash them separately with a detergent explicitly designed for radioisotope work. Store these glassware in a separate marked area. Decontamination of these exposed glasswares must be done properly before being returned to general use.
- Use only one sink for cleaning of contaminated glassware and equipment. Label this sink with proper radiation warning signs.
- In order to prevent the spread of radioactive spills, cover it with absorbent materials. The spill area must be marked to warn others. In this case, initiate the decontamination of the area as soon as possible.
- Usually, equipment may be washed with a proper laboratory detergent. Use chelating agent or ultrasonic cleaning if necessary. Unsatisfactorily decontaminated equipment must be stored separately until the radiation has decayed sufficiently or it must be discarded as radioactive waste.
- To encourage laboratory users to remove contaminated clothing before leaving the laboratory, coat hooks must be installed near the exit door.
- Before starting maintenance in radioisotope laboratory, locally decontaminate the working area.
- All users must wash their hands after using radioisotope laboratory.

7.5.3. Cold Room Safety

The intention of cold rooms is to properly store certain agents and to conduct certain tests at a controlled temperature.

The supplied air in cold rooms is intended to prevent the buildup of carbon dioxide generated from users in the room as well as other contaminants that might be released in the room. Nevertheless, this small volume of supplied air creates moisture problems contributing to mold growth, especially when trace contaminants are present on surfaces.

To that extent, these guidelines are recommended to minimize mold growth, recommend correct chemical and biological use and storage, and list some activities that are prohibited. Users can experience inhalation exposures to mold and a buildup of carbon dioxide when they are in cold rooms.

Guidelines

Minimizing Potential Mold Growth

In many cold rooms various molds are available. A cold room contamination with mold can happen quickly if an improper procedure occurs. It results to potential health problems from breathing of the mold spores and contamination of used materials.

The storage of cellulose containing materials leads to mold growth. Also, mold growth can lead to contamination of research substances. Mold growth in cold rooms can be prevented by controlling condensation/moisture and removing materials. The following procedures can be considered:

- Clean up spilled liquids (e.g., buffers, media). Mold growth can initiate on an organic medium.
- Inform water leaks to LS/LSS.
- Keep door shut to prevent condensation. Left open doors can increase the relative humidity in the working area which supports mold growth.
- Damaged door gaskets can provide a cold surface resulting in condensation problems. Be aware of condensation on other sections as well. Sometimes condensation is an sign of decontamination. Inform LS for an assessment of the problem.
- Eliminate all wood. Wood can absorb moisture and, since it is composed of cellulose, it is a perfect ground for mold growth. Wood shelves must be replaced with stainless steel shelves that allow air flow throughout the storage area.
- Eliminate all products which contain cellulose, such as cardboard and paper. These surfaces act like wood and promote mold growth. If paper products are required, store them in an enclosed plastic container between uses. If visible mold found on a paper product, throw away the item immediately.
- Keep surfaces clean. Do not use bleach on metal surfaces, because bleach on metal surfaces can result in pitting. Wet clean-up activities are recommended. For example, dusting, sweeping or brushing will spread mold into the air and can cause breathing exposures and spread potential contamination.
- If you need minor cleaning, use following wet clean up method. For example, dampen cloth with a non-ammoniated soap or detergent (do not combine ammonia and bleach; produced fumes are highly toxic).
- If mold reappears soon after cleaning, use any hospital approved disinfectant, drying surfaces after cleaning to ensure moisture has been removed.
- Users will be held responsible for cleaning mold growth if LS/LSS inspections note improper actions that could contribute to mold growth.

Proper Chemical Use and Storage

Cold rooms can recirculate the air contained within. Vapor of chemicals in the air can accumulate and pose a breathing exposure or an explosion hazard to laboratory users. Therefore:

- Flammable solvents can spread sufficient vapors to form an explosive atmosphere. Fans and electrical laboratory equipment in these rooms are potential ignition sources. Do not store large quantities (>1 liter) of flammable solvents in cold rooms. A standard refrigerator must never be used for the storage of flammable materials. Instead, use flammable storage refrigerators.
- Cold rooms have a contained atmosphere, some **hazardous chemicals** such as chloroform, formaldehyde which are not flammable may vaporize and cause exposures to users. All users should consider the risk when applying experiment procedures and evaluate those procedures where vapors are released in a chemical fume hood. Quantities need to be limited to less than 250 mL (note: chemicals such as chloroform vaporize very quickly. Such chemicals should NOT be placed in squeeze dispenser bottles.
- In cold rooms, prompt removal of the spilled materials is essential.

Prohibited activities

To provide the safety of all users, the following activities are forbidden in cold rooms:

- Storage of food and beverage: Storage of any beverages or food is explicitly prohibited.
- Usage of **compressed gas**: Gases released from incubators in a cold room can cause a lowering of the oxygen level, resulting in possible asphyxiation. Gases must be used outside of a cold room. In case of a gas usage in a cold room, an oxygen sensor which is equipped with a local alarm, must be installed in the cold room in order to warn other users if a low oxygen level occurs.
- Never store dry ice in a walk-in cooler. Dry ice can create an oxygen deficient atmosphere when it sublimes and releases gaseous carbon dioxide.
- A single individual may create problems affecting all users since most cold rooms are shared

between multiple groups. If there is a problem, the Responsible Faculty Member or LS, and furthermore all users, must take the appropriate action to resolve the issue.

LS will notify users of cold rooms of improper use issues.

7.6. EMERGENCIES, EXPOSURES AND SPILLS

7.6.1. Emergency Types

There are three types of emergencies:

- Disasters due to fires, floods and earthquakes
- Biohazardous spills
- Spills which involve multiple hazards

General Emergency Procedures

- **Alert** others
- **Confine** the problem (if possible without undue risk)
- **Turn** off ignition sources
- **Leave** ventilation on
- **Evacuate**, if necessary
- **Close** doors
- Call from a secure area
- Give name, phone number, location, type of emergency
- Remain near phone to assist responders

For more information please see **Emergency Procedures**.

7.6.2. Exposures and Injuries

The procedures, activities, personnel attitudes, and equipment that create conditions favorable for occupational laboratory infections are similar to those that lead to the occurrence of industrial type accidents.

The extra ingredient is the presence of biohazardous agents capable of causing human infections.

Laboratory events that might create hazards, exposures, or accidents requiring reporting could be classified in two categories:

- Events occurring during work with biohazardous materials or in a biohazardous area that could result in physical injury, cuts, burns, abrasions, or fractures.
- Events occurring during the handling of biohazardous agents, infected specimens, or animals that could allow release of the agent to the environment or its undesired transfer to employees, animals or cultures.

In the first category the injury site could be contaminated with the biohazardous agent in use. In the second category illness or unwanted cross contamination could occur without physical injury.

Mechanisms of infection typical of the second category are ingestion of contaminated fluids, exposure to aerosols, and penetration of agents through the unbroken skin.

Therefore, for the purpose of controlling biohazards, all accidents, known exposures, and potential hazards must be identified and reported.

7.7.2.1. Skin and eye contact

By direct contact with the skin or eyes, chemicals can easily enter the body resulting a local reaction, such as a burn or rash, or absorption into the bloodstream. If there is an absorption into the bloodstream, the chemical may cause toxic effects on other parts of the body. The SDS usually includes information regarding if skin absorption is an important way of exposure.

Health of the skin and the properties of the chemical influence the chemical absorption through the skin. The resistance of a skin, which is dry or cracked, is low. Organic solvents can easily penetrate skin which changes the resistance of the skin to other materials.

Gloves and other protective clothing should be worn to reduce skin exposure. Skin exposure shows symptoms like dry, whitened skin, redness and swelling, rashes or blisters, and itching. If there is chemical contact on skin, the clothes should be removed and the affected area hould be rinsed with water. If symptoms continue, medical care should be taken.

If the eyes are exposed to chemicals, painful injury or loss of sight may be seen. Safety goggles or a face shield should always be worn to reduce the risk of eye contact. Eyes that have been in contact with

chemicals should be rinsed immediately with Diphoterine or water continuously for at least 15 minutes and the contact lenses should be removed while rinsing. If symptoms continue, medical care should be taken.

7.7.2.2. Inhalation

Gases, vapors, particles, and aerosols (smoke, mists and and fumes) can easily penetrate into the respiratory system and may be transported into the lungs or be absorbed into the bloodstream. The vapor pressure of the material, solubility, particle size, its concentration in the inhaled air, and the chemical properties of the material influence the absorption of these materials into the respiratory system. If the vapor pressure is high, this means a substance can quickly evaporate into the air and the concentration in air can increase. Higher concentrations in air cause greater exposure in the lungs and greater absorption in the bloodstream. As most of the chemicals have an odor, there is no relationship between odor and toxicity. There is considerable individual variability in the perception of odor. The odor may seem to disappear as fatigue may occur when the lab user is exposed to high concentrations of chemicals; but the danger of over-exposure remains. Headaches, increased mucus production, and eye, nose and throat irritation are included in the symptoms of over-exposure. In addition, many solvents may induce narcotic effects, including confusion, dizziness, drowsiness, or collapse. containers should be closed and the ventilation should be increased in the event of exposure. If symptoms continue, medical care should be taken.

To reduce the exposure capacity, volatile hazardous materials should be used in a well-ventilated area, rather a fume hood. Respirators should also be used in the case of inadequate ventilation and bad

working fume hoods. The use of a respirator is subject to prior review by LS/LSS according to SU Policy. See **Personal Protective Equipment** for more information.

7.7.2.3. Ingestion

Toxic substances can also penetrate from the gastrointestinal tract. Chemicals direct ingestion may not be possible, but the lab user may be exposed to the chemicals by ingesting contaminated food or beverages, touching the mouth with contaminated fingers, or swallowing inhaled particles. Therefore, to reduce the possibility of this kind of exposure, users should not eat, drink, smoke or store food in the working area and hands should always be washed after working with chemicals, even when gloves were worn.

In the event of accidental ingestion, immediately go to Health Center or contact LSS for instructions. Do not vomit unless directed to do so by a health care provider.

7.7.2.4. Injection

Injection is the final possible way of exposure to chemicals. Syringe needles, handling animals, or accidents with pipettes, broken glassware or other sharp objects that have been contaminated with toxic substances may cause injection. Direct access to the bloodstream, thus, to internal organ systems is provided by injection.

In the incident of injection, the area should be washed with soap and water and if possible, Health Center should be called from 7666. Cautious use of any sharp object is always important. For supplying protection from the injection, cannulas should be substituted for syringes and gloves should be worn.

7.6.3. Spills of Biological Material

The consequences of any spill of biological material can be minimized by performing all work on plastic-backed absorbent liner to absorb spills.

A well designed spill kit is highly recommended. It can save injury, time, and resources. For a **Biohazard Spill Kit**, the following items are highly necessary:

- A chemical decontaminant; generally a 10% household bleach solution is appropriate, the following fact should be kept in mind: Bleach will corrode stainless steel if left in contact with it for 30 minutes or more. For human blood and body fluids, iodophors or 70% alcohol is appropriate.
- Absorbant materials for liquids after decontamination; paper towels, absorbent lab pads, or special materials designed to absorb large volumes of liquid are appropriate.
- Appropriate personal protective equipment; gloves and a long-sleeved laboratory coat or gowns, also facial protection are necessary during the clean-up procedure. Additional personal protective equipment is necessary when working with Class 3 agents.
- A mechanical means for handling broken glass; tongs, forceps, small disposable scoops and

sponges, autoclavable dust pans, or any other method that prevents direct contact with the broken glass are necessary.
- Biohazard bags, autoclavable bags sharps containers, and/or other containers to place the material in for further treatment and disposal.

7.7.3.1. Bio safety level 1 organism spill

Risk Group 1 infectious agents are biological agents that are unlikely to cause disease in healthy workers or animals (low individual and community risk).

- Wear disposable gloves.
- Soak paper towels in disinfectant and place over the spill.
- Place towels in a plastic bag for disposal.
- Clean up spill area with fresh towels soaked in disinfectant.

7.7.3.2. Bio safety level 2 organism spill (moderate risk agents)

Risk Group 2 infectious agents are pathogens that can cause human or animal disease but, under normal circumstances, are unlikely to be a serious hazard to laboratory users, the community, livestock, or the environment (moderate individual risk, limited community risk). Laboratory exposures rarely cause infection leading to serious disease; effective treatment and preventive measures are available and the risk of spread is limited.

- Alert people in the immediate area of the spill.
- Put on protective equipment. This may include a laboratory coat with long sleeves, back-fastening gown or jumpsuit, disposable gloves, disposable shoe covers, safety goggles, mask or full-face shield.
- Cover the spill with paper towels or other absorbent materials.
- Carefully pour a freshly prepared 1 to 10 dilution of household bleach around the edges of the spill and then into the spill. Avoid splashing.
- Allow a 20-minute contact period.
- After the spill has been absorbed, clean up the spill area with fresh towels soaked in disinfectant.
- Place towels in a plastic bag and decontaminate in an autoclave.

7.7.3.3. Bio safety level 3 organism spill

Risk Group 3 infectious agents are pathogens that usually cause serious human or animal disease, or which can result in serious economic consequences, but do not ordinarily spread by casual contact from one individual to another (high individual risk, low community risk), or that can be treated by antimicrobial or antiparasitic agents.

- Do not breathe; leave the room immediately and close the door.
- Notify others in the room to evacuate immediately, and assist others if necessary.
- Remove personal protective equipment in the airlock or access zone, turn potentially contaminated clothing outward, remove gloves last, and wash any exposed skin areas with antiseptic soap and warm water.
- Warn others not to enter the contaminated area. Place an appropriate sign on the door.
- Wait at least 30 minutes to allow dissipation of aerosols created by the spill.
- Put on a long sleeved gown, gloves, appropriate respirator, and rubber boots, if required, before re-entering the room.
- Cover the spilled area with paper towels or disinfectant soaked paper towels.
- Slowly pour appropriate decontaminant solution around the spill and allow to flow into the spill. Avoid splashing or the creation of aerosols during this step.
- Let stand at least 15 - 20 minutes to allow adequate contact time.
- Using an autoclavable dust pan and squeegee, transfer all contaminated materials (paper towels, glass, liquid, gloves, etc.) into a deep autoclave pan, and autoclave promptly.
- Repeat the decontamination procedures.
- The dust pan and squeegee should be placed in an autoclave bag and autoclaved as well.

7.7.3.4. Spill Involving human blood and body fluids

- Alert people in immediate area of spill.
- Any employee exposed to human blood and body fluids must cleanse the affected areas as soon as possible:
  Skin contact/cuts/puncture wounds: wash with soap and water, then pour 3% hydrogen peroxide over the cut/lesion or wash with either chlorhexidine or iodophor.
  Eyes: flush with water
  Mouth: rinse well with 3% hydrogen peroxide and then water.
- Inform the LS or Responsible Faculty Member in case of exposure.
- A properly trained employee must proceed with the cleanup and decontamination of the spill

area.
- Put on protective equipment (full face shield or mask and safety glasses/goggles, latex gloves, lab coat).
- Pick out any sharps using tongs or other mechanical means and cover spill absorbent material such as paper towels.
- Carefully pour a freshly prepared 1/10 dilution of household bleach around the edges of the spill and then into the spill. Avoid splashing.
- Allow a 20 minute contact period.
- Use paper towels to wipe up the spill, working from the edges into the center.
- Clean spill area with fresh paper towels soaked in bleach solution.
- Place towels in a red bag for disposal.
- Remove protective equipment and wash hands thoroughly.

7.7.3.5. Spills within a biological safety cabinet

- Leave the ventilation on.
- All items within the cabinet should be disinfected (Walls and surfaces wiped down, equipment wiped down and/or autoclaved).
- Cover the spill area with paper towels or absorbent material.
- Soak the spill area with an appropriate disinfectant (i.e. 10% bleach). Pour the disinfectant from the outside surface of the absorbent material towards the inside.
- Leave on for 20 to 30 minutes.
- Pick up with absorbent material.
- All waste should be autoclaved.
- Ventilation should run for 10-15 minutes.
- If the spill overflows onto the interior of the BSC contact LS or the technical service as a more extensive decontamination may be required.

7.7.3.6. Spills inside a centrifuge

- Leave lid closed and allow aerosols to settle for at least 1 hour (ensure centrifuge is off).
- Notify others in the lab not to use the centrifuge (include signage) and inform the lab supervisor.
- If possible move the centrifuge or at least the rotors and buckets to a BSC.
- Disinfect the centrifuge or rotors and buckets in an appropriate disinfectant, allow at least 20 to 30 minutes of contact time.
- Carefully retrieve any broken glass from inside the centrifuge using forceps and place in a sharps container.
- Drain the disinfectant.
- Thoroughly wipe down the inside of centrifuge and all parts including the lid with paper towels soaked in disinfectant.
- Rinse both the rotors and the inside of the centrifuge with water if bleach was used.
- All waste should be autoclaved.

7.7.3.7. Spills outside of a biological cabinet, in a laboratory

Biological spills outside biological safety cabinets will generate aerosols that can be dispersed in the air throughout the laboratory. These spills are very serious if they involve microorganisms that require Biosafety Level (BSL) 3 containment, since most of these agents have the potential for transmitting disease by infectious aerosols.

- Notify others.
- If an aerosol is generated (or the risk exists), hold your breath and quickly leave the lab. Close the door and post a warning sign. Evacuate the area for at least 30 minutes to allow aerosols to settle.
- Remove any contaminated clothing. For more hazardous substances place the contaminated clothing in an appropriate bag for autoclaving.
- Thoroughly wash exposed skin with soap and water.
- Assemble cleaning supplies and **PPE**.
- Cover the spill area with paper towels or absorbent material.
- Using an appropriate concentrated disinfectant cover the spill area. Pour disinfectant from the outside, towards the inside of the spill.
- Pick up any broken glass with forceps and place in a sharps container.
- Cover with absorbent material. For more hazardous substances, allow the disinfectant to act for 20 minutes.
- All adjacent areas should also be disinfected or wiped down.
- All waste should be autoclaved.
-

7.7.3.8. Spills outside the laboratory (during transport)

If a biohazardous agent is spilled during transport outside the laboratory, the main difference from the first procedure is to initiate the clean-up immediately. Otherwise, use those procedures.

Because it would already be too late to prevent aerosolization in this case, it is better to place extra emphasis on prevention of spills during transport:

- Develop a procedure for the removal of biohazardous materials for incubation, refrigeration, or for any other reason from the laboratory, and enforce adherence to it.
- Place all such materials in an unbreakable container that would prevent the escape of liquid or aerosol if it were dropped. 2 – 4 liter paint pails are good examples of acceptable containers.
- Label the container with the biohazard symbol to ensure no mistake is made as to the contents
- Viable organisms should only leave the laboratory in a well-sealed primary (inner) and secondary (outer) container with a closable top. A test-tube rack inside a tray is not acceptable.
- The exterior of the secondary container should be wiped down with disinfectant prior to leaving the laboratory so that it can be transported without wearing gloves.
- Carry paper towels and if a spill occurs use the towels to cover the spill but do not attempt a clean-up without appropriate disinfectant and personal protective equipment.
- Notify people in the immediate area and collect clean-up material and proceed with clean-up.

7.7. PERSONAL PROTECTIVE EQUIPMENT

To reduce the exposure to potentially infectious materials, personal protective equipment (**PPE**) should be properly used. When engineering controls and work practices do not supply enough protection, PPE is to be considered as the "last line of defence". Here, necessary biosafety PPE is summarized.

7.7.1. Gloves

Working with infectious materials requires wearing gloves. Due to the fact that users may be allergic to latex gloves, nitrile or vinyl gloves should be used instead of latex. Those who prefer latex should use only powder-free gloves.

Corrosives and organic solvents may penetrate gloves or reduce their protective ability; so different types of gloves should be stockpiled in the laboratory.

When using any glove:

- Check for visible tears and other defects.
- Remove rings and other jewellery if they are able to rip gloves.
- Change gloves regularly or as soon as possible if they are obviously contaminated.
- Wash hands immediately after removing gloves.
- Remove gloves when leaving the laboratory; even if they are "clean".

7.7.2. Eye Protection

Following should be done for providing eye protection.

- Safety glasses with side shields are necessary which provide minimum level of protection for handling any hazardous material.
- When doing activities with a small splash hazard or working with organisms transmissible through mucous membrane exposure, goggles are necessary, which fit firmly all around the eyes.
- Face shields should be used with goggles when there is an elevated risk of large quantity splashes or if the user is working with highly toxic, corrosive, or infectious materials. Face shields must also be used for protection against UV radiation (be sure that the face shield carries the manufacturer's validation of UV protection) and when handling liquid nitrogen.

7.7.3. Lab Coats

Lab coats that are resistant to liquid penetration for activities with splash potential should be worn or a plasticized apron should be utilized. Lab coats must not be worn outside of the laboratory if they were used during work with infectious materials. For high risk activities, a rear-fastening lab coat should be worn. Provision, laundering, and replacement of lab coats is the responsibility of the LS; lab users should not wash contaminated lab coats at their home.

7.7.4. Surgical Masks

Masks will help prevent ingestion and protect the mucous membranes of the nose and mouth. They do

not provide sufficient protection against infection from organisms transmitted by inhalation, e.g., M. tuberculosis.

7.7.5. Respirators

Respirators are used when there is the risk of airborne exposure to organisms transmitted by inhalation and containment devices are unavailable or unable to provide sufficient protection. Respirator use must be preceded by medical clearance and training.

7.8. TRANSPORTATION AND SHIPMENT OF BIOLOGICAL MATERIALS

The transportation and shipment of biological materials is subjected to strict regulatory controls. Individuals involved in the transportation and shipment of infectious substances must receive training on the applicable regulations and requirements before shipping such materials.

Biological materials transported by laboratory users within a laboratory or between buildings must be contained in such a way as to prevent release to the environment in case of an accident by following the procedure below:

- Biological samples must be placed in a primary container or vessel that is a securely closed, leak-proof (or O-ring) tube, vial or ampoule, which is then placed in an unbreakable, lidded, watertight, secondary container.
- If the outside of the primary container or vessel is suspected of being contaminated, decontaminate prior to placing in secondary container using 10% bleach solution or a disinfectant appropriate for the biological material in use.
- All biohazards must be labelled with the international biohazard symbol on the outside of the secondary container.
- When transporting liquids in glass vials/containers, place enough absorbent material, such as paper towels, in the space at the top, bottom, and sides between the primary and secondary containers to absorb the entire contents of the primary container(s) in case of breakage or leakage.
- The outside of the secondary container must be free of any biohazardous material so that the package can be carried safely between buildings without wearing gloves or lab coats outside.
- The package must be taken directly to its intended location.
- If a spill occurs during transport, do not attempt to clean it up without appropriate spill response material and PPE. Keep other people clear of the spill.

7.8.1. Packaging Unregulated Biological Materials

All biological materials must be packaged according to a triple packaging system. The three components of a triple packaging system are:

- Primary receptacle
- Leak-proof secondary container
- Rigid outer container

The primary receptacle holds the biological material and must be leak-proof, watertight. It is packed in the secondary container in such a way that, under normal conditions of transport, they will not break, be punctured, or leak their contents into the secondary container. If the primary receptacle is fragile, it must be individually wrapped or separated to prevent contact between multiple primary receptacles.

The secondary container is a durable, watertight, leak-proof container that encloses and protects the primary receptacle(s). Several cushioned primary receptacles may be placed in one secondary container. If the primary receptacle contains any liquid, the secondary container must contain enough absorbent material to absorb all of the fluid from the primary receptacle(s) in case of breakage.

The outer container is a rigid and durable container with one side that is at least 10 cm x 10 cm that houses the secondary container. The outer package should be properly marked and labelled. It should be able to withstand outside influences such as physical damage while in transit. An itemized list of package contents must be included between the outer and secondary container.

7.8.2. Shipping of Biological Materials

Biological materials are classified as infectious substances (including “biological substances, category B” and “patient specimens”), biological products, genetically modified organisms, or medical/clinical waste for the purposes of shipping. The shipment of certain genetically modified organisms is also regulated.

Infectious substances - Substances which are known or are reasonably expected to contain pathogens. Pathogens are defined as micro-organisms (including bacteria, viruses, rickettsiae, parasites, fungi) and other agents such as prions, which can cause disease in humans or animals. Infectious substances are separated into the following categories:

Category A - An infectious substance which is transported in a form that, when exposure occurs, is capable of causing permanent disability, life-threatening or fatal disease to humans or animals.

Infectious substances meeting these criteria which cause disease in humans or both in humans and animals must be assigned to UN2814. Those which cause disease in only animals must be assigned to UN2900.

Assignment to UN2814 or UN2900 must be based on the known medical history and symptoms of the source human or animal, endemic local conditions, or professional judgment concerning individual circumstances of the source human or animal.

The proper shipping name for UN2814 is Infectious Substance, affecting humans. The proper shipping name for UN2900 is Infectious Substance, affecting animals.

Infectious Substances (Category A) Shipping Requirements

- Triple layer packaging (materials used for transport must be tested to ensure sample won't leak)
- Absorbent material
- Itemized contents list
- Outer package must bear Class 6.2 Infectious Substance diamond label
- Additional labelling and marking requirements
- Shipper's Declaration required

Category B - An infectious substance which does not meet the criteria for inclusion in Category A. Infectious substances in Category B must be assigned to UN3373

When transported, infectious substances (both Category A & B) are classified as dangerous goods and must be shipped in accordance with international (IATA) regulations.

Infectious Substance, Category B Requirements

- Triple layer packaging
- Materials used for transport must be tested to ensure sample won't leak
- Outer package must bear UN3373 diamond label
- Outer package and air waybill must bear "Biological Substance, Category B" statement
- No Shipper's Declaration required; only airway bill

Patient Specimens - Exempt specimens are those collected directly from humans or animals, for which there is a minimal likelihood that pathogens are present. Professional judgment should be used to determine if a substance is exempt. Examples include blood or urine tests for cholesterol levels, blood glucose levels, hormone levels, or prostate specific antigens (PSA); tests required to monitor organ function such as heart, liver or kidney function for humans or animals with non-infectious diseases, or therapeutic drug monitoring; tests conducted for insurance or employment purposes and are intended to determine the presence of drugs or alcohol; pregnancy tests; biopsies to detect cancer; and antibody detection in humans or animals.

Biological products - products derived from living organisms that are known not to produce viruses, toxins, etc. and are manufactured and distributed in accordance with requirements of national government authorities. These include, but are not limited to, finished or unfinished products such as vaccines. Biological products are not currently regulated for the purposes of shipping.

Dry Ice - In addition to the classifications and rules for potentially infectious materials, shipment of solid carbon dioxide, or dry ice, is regulated as a dangerous good regardless of the hazard classification of any other materials in the package. Dry ice may cause burns, and if packaged improperly, can result in dangerously high pressure build-up inside of a sealed contained. For these reasons, there are specific training, labelling, and packaging requirements for shipments containing dry ice.

Infectious Substance Shipments with Dry Ice Requirements:

- Never place dry ice in a sealed container
- Outer package must be approved to hold dry ice, otherwise use an over pack
- UN 1845 Dry Ice label, including estimated weight of dry ice
- Class 9 Miscellaneous Dangerous Goods label

For specific information please see material SDS using **ChemWatch**.