

Chapter 10 LABORATORY SAFETY

Introduction

The following sections provide general guidelines and requirements for laboratory safety. This chapter covers the following topics:

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General Safety Guidelines

Because laboratories involve numerous chemicals, procedures, and operations, they require extensive safety precautions. Laboratory safety involves chemical safety, fire safety, electrical safety, and other safety issues. Follow the guidelines in this chapter for general laboratory safety, but refer to other chapters in this manual for specific information.

This section discusses the following:

- Common laboratory hazards
- Controlling laboratory risks
- Safe laboratory practices
- Equipment safety

Common Laboratory Hazards

Examples of common hazards include the following:

- Chemical hazards:
 - Toxins, corrosives, flammables, and reactives
- Biological hazards:
 - Microbes, animals, plants, and genetically modified agents

- Radiation hazards:
 - Ionizing and nonionizing radiation
- Physical hazards:
 - Heating devices, noise, projectiles, fire, cold, etc.
- Electrical hazards:
 - Fire and shock
- Mechanical hazards:
 - Moving machinery
- Airborne hazardous materials:
 - Vapors, dust, etc.
- Ergonomic factors:
 - Standing, repetitive motion

Controlling Laboratory Risks

Administrative and engineering controls can help minimize laboratory risks. However, safety conscious workers using good laboratory practices are the most important component of laboratory safety. The following factors are important for safe laboratory operations:

- Adequate facilities:
 - Proper ventilation
 - Non-slip surfaces
 - Hand washing facilities
- Available and appropriate safety equipment:
 - Personal protective equipment
 - Laboratory equipment
 - Safety devices on laboratory equipment, machines, devices, and instruments
- Appropriate emergency equipment:
 - Fire extinguishers
 - Emergency showers
 - Eye wash stations
- Appropriate procedures:
 - Good housekeeping
 - Personal hygiene (e.g., washing hands)

- Knowledgeable workers:

Experienced
Trained

All laboratory doors should be labeled with emergency contact information. If an incident occurs during off-hours, respondents need to know the names and telephone numbers of the people responsible for laboratory operations. Keep this information current and accurate. Emergency contact labels are available from the Safety & Health Office.

Properly trained and experienced workers have the greatest ability to control laboratory risks. By using good laboratory practices, workers can minimize hazards, exposure, contamination, and workplace accidents.

Safe Laboratory Practices

To ensure laboratory safety, follow safe laboratory practices, including the following:

- Know about the chemicals and hazards associated with your laboratory.
- Know what to do in different emergency situations.
- Know how to read and interpret MSDSs.
- Wear personal protective equipment, as appropriate.
- Follow safe practices for working with chemicals. (Refer to the Chemical Safety chapter for more information.)
- Ice from a laboratory ice machine should not be used for human consumption.
- Dedicate microwave ovens and other heating devices exclusively for food or for laboratory operations. Ensure that ovens are clearly labeled to indicate their function.
- Do not wear contact lenses around chemicals, fumes, dust particles, or other hazardous materials.
- Protect unattended operations from utility failures and other potential problems that could lead to overheating or other hazardous events.
- Avoid working alone in a laboratory.
- Avoid producing aerosols.
- Use extreme care when working with needles, blades, and glass.
- Do not eat, drink, or use tobacco products in the laboratory.
- Do not mouth pipette.
- Clean contaminated equipment and spills immediately. Avoid contaminating equipment with mercury. Clean mercury spills immediately. (Chronic exposure to mercury can result from a few drops left uncleaned.)
- Do not allow children in the laboratory. (It is a violation of state law for a child to be unattended in a place that presents a risk of harm.)
- Keep laboratory doors closed.
- Decontaminate all affected equipment.
- Avoid using dry ice in enclosed areas. (Dry ice can produce elevated carbon dioxide levels.)
- Dry ice mixed with isopropanol or ethanol may cause frostbite.
- Hallways, corridors, and exit ways must be kept clear. Do not locate (even temporarily) laboratory equipment or supplies in these areas.

IMPORTANT:

Never underestimate the hazards associated with a laboratory. If you are unsure about what you are doing, get assistance. Do not use unfamiliar chemicals, equipment, or procedures alone.

Equipment Safety

There are four fundamental elements of equipment safety: (1) use the correct equipment, (2) know how to operate the equipment, (3) inspect the equipment, and (4) use the equipment properly.

Use equipment for its intended purpose only. Do not modify or adapt equipment without guidance from the equipment manufacturer or the Safety & Health Office. Do not defeat, remove, or override equipment safety devices.

Working in a laboratory requires various types of equipment. To ensure equipment safety, you must be familiar with the following:

- Equipment operation
- Applicable safeguards
- Maintenance requirements

Always inspect equipment before using it. Ensure that the equipment meets the following requirements:

- Controls and safeguards are adequate and functional.
- Location is safe (and well ventilated, if necessary).
- Equipment works properly.

IMPORTANT:

Disconnect any equipment that is unsafe or does not work properly, and remove it from service. Notify other users of the problem.

Refer to other sections in this manual for specific information on operating laboratory equipment, such as fume hoods, heating devices, vacuums, etc.

Laboratory Safety Inspections

Laboratory Safety Inspections are required to insure our labs are as safe as possible. All inspections must be conducted using the “Laboratory Safety Evaluation” form, Appendix C.

Teaching Laboratories

Teaching Laboratories shall be inspected the lab staff. Quarterly inspection reports are to be sent to the Office of Environmental Safety & Health.

Research Laboratories

Research Laboratories shall be inspected by the faculty member to whom the lab is assigned. Quarterly inspection reports are to be sent to the Office of Environmental Safety & Health.

Annual Inspections by Office of Environmental Safety & Health.

All labs will be inspected annually by the Office of Environmental Safety & Health and the Laboratory Policy and Safety Committee. If deficiencies are noted that cannot be corrected during the inspection, a follow-up inspection will be performed at sixty days, and every 60 days thereafter, until said deficiencies are corrected. If a situation is discovered during an inspection that poses an immediate threat to employee or public health, the Office of Environmental Safety & Health may order all operations in the lab to cease

until the problem is corrected. Inspection reports shall be sent to the Dean of the College of Arts & Sciences and to the person responsible for the lab.

Aerosol Production

The term "aerosol" refers to the physical state of liquid or solid particles suspended in air. Aerosols containing infectious agents and hazardous materials can pose a serious risk because:

- Small aerosol particles can readily penetrate and remain deep in the respiratory tract, if inhaled.
- Aerosols may remain suspended in the air for long periods of time.
- Aerosol particles can easily contaminate equipment, ventilation systems, and human skin.

The following equipment may produce aerosols:

- Centrifuge
- Blender
- Shaker
- Magnetic stirrer
- Sonicator
- Pipette
- Vortex mixer
- Syringe and needle
- Vacuum-sealed ampoule
- Grinder, mortar, and pestle
- Test tubes and culture tubes
- Heated inoculating loop
- Separatory funnel

Follow these guidelines to eliminate or reduce the hazards associated with aerosols:

- Conduct procedures that may produce aerosols in a biological safety cabinet or a chemical fume hood.
- Keep tubes stoppered when vortexing or centrifuging.
- Allow aerosols to settle for one to five minutes before opening a centrifuge, blender, or tube.
- Place a cloth soaked with disinfectant over the work surface to kill any biohazardous agents.
- Slowly reconstitute or dilute the contents of an ampoule.
- When combining liquids, discharge the secondary material down the side of the container or as close to the surface of the primary liquid as possible.
- Avoid splattering by allowing inoculating loops or needles to cool before touching biological specimens.
- Use a mechanical pipetting device.

Animals and Hazardous Materials

Any research or instructional use of hazardous materials associated with live animals requires the submission of an Animal Use Protocol to the Institutional Animal Use and Care Committee. The Protocol must be fully approved before any researcher may acquire, house, or use animals.

IMPORTANT:

With the increasing prevalence of animal testing, there comes a greater need to protect researchers. Consider both the direct hazards associated with research animals and the hazardous metabolic byproducts produced by research animals.

Animals and Toxic Chemicals

Animal research or testing with toxic chemicals (including known or suspected carcinogens) may produce aerosols, dusts, or metabolic byproducts that contain toxicants. The animal bedding, equipment, and surrounding atmosphere may become contaminated.

When working with research animals and toxic chemicals, always wear gloves and button your laboratory coat. If aerosol production cannot be controlled, use a respirator. Follow all instructions outlined in the approved Animal Use Protocol for handling these agents.

A respirator with a HEPA filter will protect you from airborne particulates, but it will not protect you from chemical vapors. Wetting animal bedding before cleanup will help reduce aerosols.

Animals and Infectious Agents

Personnel performing animal research with infectious agents or working with animals that carry potential diseases must utilize isolation procedures. The extent of isolation must be appropriate for the infection risk. Any work with these agents and animals that could shed these agents must be approved by the Institutional Animal Use and Care Committee. Examples of zoonotic diseases that pose a hazard to humans include the following:

- Brucellosis
- Salmonellosis
- Shigellosis
- Pasteurellosis
- Tularemia
- Tuberculosis
- Ringworm
- Herpes B-virus
- Rabies
- Viral hepatitis
- Q Fever

Conduct work with infectious agents according to good laboratory procedures and containment practices. For information on proper disposal methods, refer to the Biological Safety chapter in this manual.

Animals and Recombinant Genetic Materials

Animal research with recombinant DNA (rDNA) must be conducted in accordance with NIH guidelines and UTPB requirements. Because containment and disposition is a critical concern, all experiments involving rDNA or genetically altered animals (including recombinants, transgenics, and mosaics) must receive prior approval from the UTPB Institutional Biosafety Committee.

Animals and Radioactive Materials

A UTPB Radiation Safety Officer must approve the use of radioactive materials in animals. Permits to use radioisotopes must be acquired through the Radiation Safety Officer.

Mechanical Injury Hazards

Mechanical injury is the most common hazard associated with animal research. Animals are capable of inflicting extensive injury to humans. Most research animals can bite or scratch. Livestock, large animals, and primates can bite, batter, or crush. Because disease and infection are easily spread by bites and scratches, researchers must take special care when working with animals.

Animal Allergies

Researchers who work with animals may develop allergic reactions, including rhinitis, conjunctivitis, asthma, and dermatitis. Symptoms of animal allergy may include nasal congestion, sneezing, watery eyes, hives, and eczema.

Rabbits and rodents are the most common research animals that cause severe allergic reactions. Animal dander, fur, bedding, urine, saliva, and tissues are the primary sources of allergic antigens. Mold spores and proteins in animal feed may also act as antigens.

To reduce exposure to animal allergens, minimize the generation of aerosols and dust and wear protective equipment. Take special care to wear respiratory protection and gloves when feeding animals, handling animals, changing bedding, or cleaning cages.

Indirect Animal Hazards

Indirect hazards occur when research animals are intentionally exposed to biological agents, chemicals, and radioactive materials. Because animal bedding, equipment, waste products, and surrounding atmosphere may become contaminated, these items can be hazardous. To protect personnel, manage all animal products and areas according to specific procedures approved by the appropriate oversight committee.

NOTE:

See the Agriculture Safety chapter for more information pertaining to the safe handling of livestock.

Centrifuges

Centrifuging presents the possibility of two serious hazards: mechanical failure and aerosols. The most common hazard associated with centrifuging is a broken tube. To ensure safety when operating a centrifuge, take precautions to ensure the following:

- Proper loading (accurate balancing)
- Safe operating speeds (do not exceed manufacturer recommendations)
- Safe stopping
- Complete removal of materials
- Proper cleanup

Follow these guidelines when working with a centrifuge:

- When loading the rotor, examine the tubes for signs of stress, and discard any tubes that are damaged.
- Inspect the inside of each tube cavity or bucket. Remove any glass or other debris from the rubber cushion.
- Ensure that the centrifuge has adequate shielding to guard against accidental flyaways.

- Use a centrifuge only if it has a disconnect switch that deactivates the rotor when the lid is open.
- Do not overfill a centrifuge tube to the point where the rim, cap, or cotton plug becomes wet.
- Always keep the lid closed during operation and shut down. Do not open the lid until the rotor is completely stopped.
- Do not brake the head rotation by hand.
- Do not use aluminum foil to cap a centrifuge tube. Foil may rupture or detach.
- When balancing the rotors, consider the tubes, buckets, adapters, inserts, and any added solution.
- Stop the rotor and discontinue operation if you notice anything abnormal, such as a noise or vibration.
- Rotor heads, buckets, adapters, tubes, and plastic inserts must match.
- Low-speed and small portable centrifuges that do not have aerosol-tight chambers may allow aerosols to escape. Use a safety bucket to prevent aerosols from escaping.
- High-speed centrifuges pose additional hazards due to the higher stress and force applied to their rotors and tubes.

In addition to the safety guidelines outlined above, follow these guidelines for high-speed centrifuges:

- Filter the air exhausted from the vacuum lines.
- Keep a record of rotor usage, in order to avoid the hazard of metal fatigue.
- Frequently inspect, clean, and dry rotors to prevent corrosion or other damage.
- Follow the manufacturers operating instructions exactly.

Compressed Gases

Compressed gases in the laboratory present chemical and physical hazards. If compressed gases are accidentally released, they may cause the following:

- Depleted oxygen atmosphere
- Fire
- Adverse health effects

Cylinders that are knocked over or dropped can be very dangerous and can cause serious injuries. If a valve is knocked off a compressed gas cylinder, the cylinder can become a lethal projectile. Because disposal of compressed gas cylinders is difficult and expensive, be sure to arrange a return agreement with suppliers prior to purchase.

IMPORTANT:

Cylinders can travel through walls much like a torpedo travels through water. They can cause structural damage, severe injury, and death.

Follow these guidelines to ensure safe storage of gas cylinders:

- Secure all cylinders in racks, holders, or clamping devices. Fasten cylinders individually (not ganged) in a well ventilated area.
- Do not rely on color to identify container contents. Check the label.
- Close valves, and release pressure on the regulators when cylinders are not in use.
- Minimize the number of hazardous gas cylinders in a laboratory. Do not exceed the following:

Three 10" x 50" flammable gas and/or oxygen cylinders, and

Two 9" x 30" liquefied flammable gas cylinders, and

Three 4" x 15" cylinders of severely toxic gases (e.g., arsine, chlorine, diborane, fluorine, hydrogen cyanide, methyl bromide, nitric oxide, phosgene).

- Keep heat, sparks, flames, and electrical circuits away from gas cylinders.
- Store cylinders of flammable and oxidizing agents at least 20 feet apart, or separate these items with a firewall.
- Do not store gas cylinders in hallways or public areas.

When working with compressed gas cylinders, remember the following:

- Never move a gas cylinder unless the cylinder cap is in place and the cylinder is chained or otherwise secured to a cart.
- Do not move a cylinder by rolling it on its base.
- Only use regulators approved for the type of gas in the cylinder.
- Do not use adapters to interchange regulators.
- When opening a cylinder valve, follow these guidelines:

Direct the cylinder opening away from people.

Open the valve slowly.

- If a cylinder leaks, carefully move the cylinder to an open space outdoors. Have the supplier pick up the cylinder.
- Do not use oil or other lubricant on valves and fittings.
- Do not use oxygen as a substitute for compressed air.
- Do not lift cylinders by the cap.
- Do not tamper with the safety devices on a cylinder. Have the manufacturer or supplier handle cylinder repairs.
- Do not change a cylinder's label or color. Do not refill cylinders yourself.
- Do not heat cylinders to raise internal pressure.
- Do not use compressed gas to clean your skin or clothing.
- Do not completely empty cylinders. Maintain at least 30 psi.
- Do not use copper (>65% copper) connectors or tubing with acetylene. Acetylene can form explosive compounds with silver, copper, and mercury.
- Always wear impact resistant glasses or goggles when working with compressed gases.

Cryogenic Liquids

Cryogenic fluids, such as liquid air, liquid nitrogen, or liquid oxygen, are used to obtain extremely cold temperatures. Most cryogenic liquids are odorless, colorless, and tasteless when vaporized. When cryogenic liquids are exposed to the atmosphere, however, they create a highly visible and dense fog. All cryogens other than oxygen can displace breathable air and can cause asphyxiation. Cryogens can also cause frostbite on exposed skin and eye tissue.

Cryogens pose numerous hazards. For example, cryogenic vapors from liquid oxygen or liquid hydrogen may cause a fire or explosion if ignited. Materials that are normally noncombustible (e.g., carbon steel) may ignite if coated with an oxygen-rich condensate. Liquefied inert gases, such as liquid nitrogen or liquid helium, are capable of condensing atmospheric oxygen and causing oxygen entrapment or enrichment in unsuspected areas. Extremely cold metal surfaces are also capable of entrapping atmospheric oxygen. Additional hazards associated with cryogenic liquids include the following:

Cryogenic Hazard Source
Hydrogen, methane, and acetylene

Hazard
Gases are flammable.

Oxygen	Increases the flammability of combustibles.
Liquefied inert gases	Possible oxygen entrapment.
Extremely cold surfaces	Oxygen atmosphere may condense.

Because the low temperatures of cryogenic liquids may affect material properties, take care to select equipment materials accordingly.

Follow these guidelines when working with cryogenic liquids:

- Before working with cryogenic liquids, acquire a thorough knowledge of cryogenic procedures, equipment operation, safety devices, material properties, and protective equipment usage.
- Keep equipment and systems extremely clean.
- Avoid skin and eye contact with cryogenic liquids. Do not inhale cryogenic vapors.
- Pre-cool receiving vessels to avoid thermal shock and splashing.
- Use tongs to place and remove items in cryogenic liquid.
- When discharging cryogenic liquids, purge the line slowly. Only use transfer lines specifically designed for cryogenic liquids.
- Rubber and plastic may become very brittle in extreme cold. Handle these items carefully when removing them from cryogenic liquid.
- Store cryogenic liquids in double-walled, insulated containers (e.g., Dewar flasks).
- To protect yourself from broken glass if the container breaks or implodes, tape the exposed glass on cryogenic containers.
- Do not store cylinders of cryogenic liquids in hallways or other public areas.

IMPORTANT:

Be aware of the tremendous expansion and threat of asphyxiation when a cryogenic liquid vaporizes at room temperature.

Electrophoresis

Electrophoresis equipment may be a major source of electrical hazard in the laboratory. The presence of high voltage and conductive fluid in this apparatus presents a potentially lethal combination.

Many people are unaware of the hazards associated with this apparatus; even a standard electrophoresis operating at 100 volts can deliver a lethal shock at 25 milliamps. In addition, even a slight leak in the device tank can result in a serious shock.

Protect yourself from the hazards of electrophoresis and electrical shock by taking these precautions:

- Use physical barriers to prevent inadvertent contact with the apparatus.
- Use electrical interlocks.
- Frequently check the physical integrity of the electrophoresis equipment.
- Use warning signs to alert others of the potential electrical hazard.
- Use only insulated lead connectors.
- Turn the power off before connecting the electrical leads.
- Connect one lead at a time using one hand only.
- Ensure that your hands are dry when connecting the leads.
- Keep the apparatus away from water and water sources.
- Turn the power off before opening the lid or reaching into the chamber.

- Do not disable safety devices.
- Follow the equipment operating instructions.

Glassware

Accidents involving glassware are the leading cause of laboratory injuries. To reduce the chance of cuts or punctures, use common sense when working with glassware. In addition, follow special safety precautions for tasks that involve unusual risks.

Follow these practices for using laboratory glassware safely:

- Prevent damage to glassware during handling and storage.
- Inspect glassware before and after each use. Discard or repair any cracked, broken, or damaged glassware.
- Thoroughly clean and decontaminate glassware after each use.
- When inserting glass tubing into rubber stoppers, corks, or tubing, follow these guidelines:

Use adequate hand protection.

Lubricate the tubing.

Hold hands close together to minimize movement if the glass breaks

- When possible, substitute plastic or metal connectors for glass connectors.
- Large glass containers are highly susceptible to thermal shock. Heat and cool large glass containers slowly.
- Use Pyrex or heat-treated glass for heating operations.
- Leave at least 10 percent air space in containers with positive closures.
- Never use laboratory glassware to serve food or drinks.
- Use thick-walled glassware for vacuum operation.
- Use round-bottomed glassware for vacuum operations. Flat-bottomed glassware is not as strong as round-bottomed glassware.

NOTE:

Do not use chromic acid to clean glassware. Use a standard laboratory detergent. Chromic acid is extremely corrosive and expensive to dispose of. Chromic acid must not be disposed in the sanitary sewer system.

Follow these safety guidelines for handling glassware:

- When handling cool flasks, grasp the neck with one hand and support the bottom with the other hand.
- Lift cool beakers by grasping the sides just below the rim. For large beakers, use two hands: one on the side and one supporting the bottom.
- Never carry bottles by their necks.
- Use a cart to transport large bottles of dense liquid.

Follow these guidelines for handling and disposing of broken glass:

- Do not pick up broken glass with bare or unprotected hands. Use a brush and dustpan to clean up broken glass. Remove broken glass in sinks by using tongs for large pieces and cotton held by tongs for small pieces and slivers.
- Glass contaminated with biological, chemical, or radioactive materials must be decontaminated before disposal or be disposed of as hazardous waste.

- Before disposing of broken glass in a trash can, place the glass in a rigid container such as cardboard and mark it "Broken Glass."

Heating Systems

Devices that supply heat for reactions or separations include the following:

- Open flame burners
- Hot plates
- Heating mantles
- Oil and air baths
- Hot air guns
- Ovens
- Furnaces
- Ashing systems

Some laboratory heating procedures involve an open flame. Common hazards associated with laboratory heating devices include electrical hazards, fire hazards, and hot surfaces.

Follow these guidelines when using heating devices:

- Before using any electrical heating device, follow these guidelines:
 - Ensure that heating units have an automatic shutoff to protect against overheating.
 - Ensure that heating devices and all connecting components are in good working condition.
- Heated chemicals can cause more damage and more quickly than would the same chemicals at a lower temperature.

RULE OF THUMB:

Reaction rates double for each 10° C increase in temperature.

- Heating baths should be equipped with timers to ensure that they turn on and off at appropriate times.
- Use a chemical fume hood when heating flammable or combustible solvents. Arrange the equipment so that escaping vapors do not contact heated or sparking surfaces.
- Use non-asbestos thermal-heat resistant gloves to handle heated materials and equipment.
- Perchloric acid digestions must be conducted in a perchloric fume hood.
- Minimize the use of open flames.

IMPORTANT:

Never leave an open flame unattended.

Pressurized Systems

Do not conduct a reaction in, or apply heat to, a closed system apparatus unless the equipment is designed and tested to withstand pressure.

Pressurized systems should have an appropriate relief valve.

Pressurized systems must be fully shielded and should not be conducted in an occupied space until safe operation has been assured. Until safe operation is assured, remote operation is mandatory.

Safety points to remember:

- Minimize risk and exposure.
- Identify and assess all hazards and consequences.
- Use remote manipulations whenever possible.
- Minimize pressure, volume, and temperature.
- Design conservatively.
- Use material with a predictably safe failure mode.
- Ensure that the components of the pressurized system will maintain structural integrity at the maximum allowable working pressure. Avoid material that may become brittle.
- Operate within the original design parameters.
- Provide backup protection (e.g., pressure relief valves, fail-safe devices).
- Use quality hardware.
- Use protective shield or enclosures.
- Use tie-downs to secure tubing and other equipment.
- Do not leave a pressurized system unattended.

IMPORTANT:

Normally pressurized systems should not include glass components unless they are specially designed and intended for that purpose.

Refrigerators/Freezers

Using a household refrigerator to store laboratory chemicals is extremely hazardous for several reasons. Many flammables solvents are still volatile at refrigerator temperatures. Refrigerator temperatures are typically higher than the flashpoint of most flammable liquids. In addition, the storage compartment of a household refrigerator contains numerous ignition sources, including thermostats, light switches, and heater strips. Furthermore, the compressor and electrical circuits, located at the bottom of the unit where chemical vapors are likely to accumulate, are not sealed.

Laboratory-safe and explosion-proof refrigerators typically provide adequate protection for chemical storage in the laboratory. Laboratory-safe refrigerators, for example, are specifically designed for use with flammables since the sparking components are located on the exterior of the refrigerator. Explosion-proof refrigerators are required in areas that may contain high levels of flammable vapors (e.g., chemical storage rooms with large quantities of flammables).

Follow these rules for using refrigerators in the laboratory:

- Never store flammable chemicals in a household refrigerator.
- Do not store food or drink in a laboratory refrigerator/freezer.
- Ensure that all refrigerators are clearly labeled to indicate suitable usage.

Laboratory-safe and explosion-proof refrigerators should be identified by a manufacturer label.

"Not Safe for Flammable Storage" labels are available from the Safety & Health Office.

Refrigerators used to hold food should be labeled "For Food Only".

Vacuum Systems

Vacuum systems pose severe implosion hazards. Follow these guidelines and requirements to ensure system safety:

- Ensure that pumps have belt guards in place during operation.
- Ensure that service cords and switches are free from defects.
- Always use a trap on vacuum lines to prevent liquids from being drawn into the pump, house vacuum line, or water drain.
- Replace and properly dispose of vacuum pump oil that is contaminated with condensate.
- Used pump oil must be disposed of as hazardous waste.
- Place a pan under pumps to catch oil drips.
- Do not operate pumps near containers of flammable chemicals.
- Do not place pumps in an enclosed, unventilated cabinet.

IMPORTANT:

All vacuum equipment is subject to possible implosion. Conduct all vacuum operations behind a table shield or in a fume hood.

CAUTION:

Do not underestimate the pressure differential across the walls of glassware that can be created by a water aspirator.

The glassware used with vacuum operations must meet the following requirements:

- Only heavy-walled round-bottomed glassware should be used for vacuum operations.
- The only exception to this rule is glassware specifically designed for vacuum operations, such as an Erlenmeyer filtration flask.
- Wrap exposed glass with tape to prevent flying glass if an implosion occurs.
- Carefully inspect vacuum glassware before and after each use. Discard or have repaired any glass that is chipped, scratched, broken, or otherwise stressed.

Glass desiccators often have a slight vacuum due to contents cooling. When using desiccators, follow these guidelines:

- When possible, use molded plastic desiccators with high tensile strength.
- For glass desiccators, use a perforated metal desiccator guard.

Cold Trap

A cold trap is a condensing device to prevent moisture contamination in a vacuum line. Guidelines for using a cold trap include:

- Locate the cold trap between the system and vacuum pump.
- Ensure that the cold trap is of sufficient size and cold enough to condense vapors present in the system.
- Check frequently for blockages in the cold trap.
- Use isopropanol/dry ice or ethanol/dry ice instead of acetone/dry ice to create a cold trap. Isopropanol and ethanol are cheaper, less toxic, and less prone to foam.
- Do not use dry ice or liquefied gas refrigerant bath as a closed system. These can create uncontrolled and dangerously high pressures.

Disinfectant Trap

A disinfectant trap should be used in-line when a vacuum is used with hazardous biological materials.

Microwaves

Microwaves are part of the electromagnetic spectrum; they range in frequency from 300 megahertz (MHz) to 300 gigahertz (GHz). Microwaves are used for communications, radar, intrusion alarms, door openers, and medical therapy, but they are most commonly used for cooking.

Metal reflects microwave radiation, but dry nonmetallic surfaces allow microwaves to pass through with little or no heating effect. Organic materials, however, are extremely heat conductive. Because microwaves can penetrate organic materials, including tissues, thermal burns and other effects may result from microwave exposure.

NOTE:

Microwave ovens are very safe when kept in good working condition and used properly. They do not serve as a source of exposure to harmful microwaves.

Even though microwave ovens are not a source of harmful radiation exposure, they should be properly used and maintained.

- Do not put metal objects (including aluminum foil) into a microwave oven.
- Do not use a microwave oven if it is damaged.
- Ensure that the seal on a microwave oven is tight, intact, and in good condition (i.e., not charred or distorted).
- Ensure that microwave ovens are clearly labeled for laboratory use or food preparation only. Microwave ovens should only be repaired by trained personnel.

Radiation-Producing Devices

Radiation-producing devices such as X-ray machines, electron microscopes, and particle accelerators are regulated through the BRC, Texas Department of Health. All radiation-producing devices must be registered with the UTPB Office of Radiological Safety.

Radiation-producing devices (other than human and veterinary diagnostic devices) shall be interlocked to prevent access to the unshielded beam during normal or routine operations. Exceptions may be granted by the UTPB Radiological Safety Officer.

IMPORTANT:

The door(s) to a room where a radiation-producing device is located should be posted with a radiation warning sign, unless the device is totally self-contained.

Super-Conducting Magnets

Super-conducting magnets may be operated in complete safety as long as correct procedures are adhered to.

Potential Hazards

1. The effect on people fitted with medical implants.
2. Large attractive forces it may exert on metal objects.
3. The effect magnetic fields have on certain equipment.
4. Large content of liquid cryogens.

Safety initiatives

1. Place warning signs on all entrances to the room where the magnet is located.
2. Safety education for all entrants to the location on the effects of magnetic fields.
3. The 5 gauss line for the magnet will be marked on the floor as a reminder of the medical and electrical danger zone.
4. Limiting large ferromagnetic objects with in the room.

Medical Implants

The operation of cardiac pacemakers may be effected by magnetic fields. There is also a possibility of harmful effects to people fitted with ferromagnetic implants. Under no circumstances should people fitted with cardiac pacemakers be allowed to approach the magnet. The .5 mT (5 gauss line) line represents a limit which is generally considered safe for medical devices. For UTPB's normal bore 250MHz magnet the 5 gauss line should be set at four foot six inches horizontally and five foot eight inches vertically from the magnet.

Attractive Force

Large attractive forces may be exerted on ferromagnetic objects brought close to the magnet. The closer to the magnet and the larger the mass, the greater the force. The attractive force may become large enough to move objects uncontrollably towards the magnet with catastrophic results. **The recommended safe limit for large objects that are easily moved (e.g. chairs, gas cylinders, hand carts) is .5 mT (5 gauss).** Gas cylinders containing gaseous Nitrogen and Helium should be securely strapped to the wall, outside the room. Smaller hand-held objects, such as screwdrivers, nuts, bolts etc., must never be left lying about on the floor close to the magnet. Dewers containing liquid Nitrogen and Helium which are normally brought close to the magnet when topping up liquid cryogen levels must be constructed of non-magnetic materials. Any ladders used when working on the magnet should be made of non-magnetic materials, such as aluminum or wood.

Effects on equipment.

Various electronic devices are affected by the magnet and should be located outside the limits specified in the following section.

5 mT (50 gauss): Magnetic power supply, RF power amplifiers.

Electrical transformers, which are a component of many electrical devices, may become magnetically saturated in fields above 5 mT. The safety characteristics of the equipment may also be affected.

2 mT (20 gauss): Magnetic storage materials e.g. credit cards, tapes, computer disks etc.

The information stored on magnetic media may be destroyed or corrupted.

0.5 mT (5 Gauss): Cathode ray tubes, monochrome computer displays.

Magnetic fields greater than 0.5 mT will deflect a beam of electrons leading to a distortion.

0.2mT (2 Gauss): Color computer displays.

Color displays are more sensitive to distortion.

0.1 mT (1 Gauss): Only very sensitive electronic equipment such as Image Intensifiers, electron microscopes will be affected.

Ultraviolet Lamps

Ultraviolet (UV) lamps are useful germicidal tools, but they also pose a potential health hazard. The following sections provide essential safety information for working with UV lamps and light.

Health Hazards

Exposure to UV radiation can cause extreme discomfort and serious injury. Therefore, you must protect your eyes and skin from direct and reflected UV light. Pay particular attention to laboratory surfaces, such as stainless steel, that can reflect UV light and increase your UV exposure.

The effect of UV radiation overexposure depends on UV dosage, wavelength, portion of body exposed, and the sensitivity of the individual. Overexposure of the eyes may produce painful inflammation, a gritty sensation, and/or tears within three to twelve hours. Overexposure of the skin will produce reddening (i.e., sunburn) within one to eight hours. Certain medication can cause an individual to be more reactive to UV light.

Personal Protective Equipment

Adequate eye and skin protection are essential when working around UV radiation. Before entering a laboratory with ultraviolet installations, you must turn off the lights or wear protective equipment (e.g., goggles, cap, gown, and gloves).

NOTE:

Safety glasses with side shields or goggles with solid side pieces are the only equipment that provide adequate eye protection against direct and reflected UV light.

Germicidal Function

UV radiation is particularly useful in the laboratory when combined with other methods for decontamination and disinfection. UV radiation is used primarily to reduce the number of microorganisms in the air and on surfaces. It is most effective against vegetative bacteria.

UV rays can only kill organisms that are invisible to the naked eye. To be effective, UV rays must directly strike the microorganisms. If microorganisms are shielded by a coating of organic material (e.g., culture medium), the UV light will be ineffective.

Maintenance

Ultraviolet lamps lose germicidal effectiveness over time and may need to be replaced even though the lamp has not burned out. It may be necessary to replace the lamp according to the manufacturer's recommendations. There are two types of UV lamps – hot cathode and cold cathode. The hot cathode lamp has two pins at each end, and the cold cathode lamp has one pin at each end. Manufacturers recommend that hot cathode lamps be replaced every six months and that cold cathode lamps be replaced every 12 months.

In addition to replacing UV lamps as indicated above, follow these guidelines to maintain UV lamps:

- Regularly wipe cool, unlit UV lamp bulbs with a soft cloth moistened with alcohol. (Dust can decrease the effectiveness of a UV lamp.)

Do not touch a UV bulb with your bare hands. The natural oils on your hand may leave a fingerprint and create dead space on the bulb's surface.