Prairie View A&M University

LABORATORY SAFETY MANUAL

Risk Management & Safety Department

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Laboratory Safety

Introduction

The following information is provided to assist Prairie View A&M University Departments in developing procedures to meet laboratory safety requirements to protect students, employees, and the environment. This program sets forth recommended **minimum requirements** that need to be followed to maximize the safety of all workers.

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- *Thanks go out to TAMU EHS Lab Safety personnel from whose manual this was based.*

I. 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 document for specific information.

This section discusses the following:

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

A. 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 non-ionizing 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

B. 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:

1. Adequate facilities:

    - Proper ventilation
    - Nonslip surfaces
    - Hand washing facilities

2. Available and appropriate safety equipment:

    - Personal protective equipment
    - Laboratory equipment
    - Safety devices on laboratory equipment, machines, devices, and instruments

3. Appropriate emergency equipment:

    - Fire extinguishers

- Emergency showers
- Eye wash stations

4. Appropriate procedures:

- Good housekeeping
- Personal hygiene (e.g., washing hands)

5. 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.

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.

C. 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.
- 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 pipet.
- 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 frost bite.
- 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.

D. 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 Office. Do not defeat, remove, or override equipment safety devices.

1. 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

2. 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 document for specific information on operating laboratory equipment, such as fume hoods, heating devices, vacuums, etc.

II. Aerosol Production

The term "aerosol" refers to the physical state of liquid or solid particles suspended in the 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
- Pipet
- Vortex mixer
- Syringe and needle
- Vacuum-sealed ampoule
- Grinder, mortar, and pestle
- Test tubes and culture tubes
- Heated inoculating loop
- Separator 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.

III. Animals and Hazardous Materials

A. Animals and Toxic Chemicals Any research or instructional use of hazardous materials in live animals requires the submission of an Animal Use Protocol to the appropriate Dean and Department Head. The Protocol must be fully approved and the Safety Office advised 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.*

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.

B. Animals and Infectious Agents Personnel performing animal research with infectious agents or working with animals that carry potential zoonoses must utilize isolation procedures. The extent of isolation must be appropriate for the infection risk. All work with these agents and animals that could shed these agents must be approved by the appropriate Dean and Department Head. 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 Program.

C. Animals and Recombinant Genetic Materials Animal research with recombinant DNA (rDNA) must be conducted in accordance with NIH guidelines and PVAMU 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 PVAMU Office of Risk Management and EHS Advisory Committee. The PVAMU RMS and TAMU Radiation Safety Officer must approve the use of radioactive materials in animals. Permits to use radioisotopes must be acquired through the RMS Department

D. 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.

E. 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.

F. 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.

IV. 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.

V. 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 fire wall.
- 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.

VI. 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	Hazard
Hydrogen, methane, and acetylene	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, 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.

VII. 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.

VIII. 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 dust pan to clean up broken glass. Remove oken 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 it must 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."

IX. 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.

X. 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:

1. Minimize risk and exposure.
2. Identify and assess all hazards and consequences.
3. Use remote manipulations whenever possible.
4. Minimize pressure, volume, and temperature.
5. Design conservatively.
6. Use material with a predictably safe failure mode.
7. Ensure that the components of the pressurized system will maintain structural integrity at the maximum allowable working pressure. Avoid material that may become brittle.
8. Operate within the original design parameters.
9. Provide backup protection (e.g., pressure relief valves, fail-safe devices).
10. Use quality hardware.
11. Use protective shield or enclosures.
12. Use tie-downs to secure tubing and other equipment.
13. 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.

XI. Refrigerators/Freezers

Using a household refrigerator to store laboratory chemicals is extremely hazardous for several reasons. Many flammable 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 Office.
- Refrigerators used to hold food should be labeled "For Food Only".

XII. 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 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 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.

A. 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.

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