2026

Laboratory Safety Manual

University of Miami
Environmental Health & Safety

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INTRODUCTION

Laboratory safety at the University of Miami is a comprehensive program managed by the Office of Environmental Health and Safety (EHS). This program encompasses Biological Safety, Chemical Safety, Hazardous Materials Management, Fire and Life Safety, Industrial Hygiene, and Laser Safety.

For any questions or concerns related to laboratory safety, EHS personnel can be reached at **305-243-3400**. EHS personnel information can be found at Contact Us | Environmental Health and Safety | University of Miami. Additional resources, including individual contact information and the latest edition of this manual, are available on the EHS website: Environmental Health and Safety | University of Miami.

Implementing Authority

EHS is responsible for providing technical guidance, oversight, consultation, training, and specialized services that support the University community in fulfilling its public health, safety, and environmental protection responsibilities.

Purpose

This manual establishes fundamental safety practices to be uniformly applied across all University of Miami laboratories. The goal is to create a safe working and learning environment for faculty, students, staff, and visitors.

Since research environments continuously evolve, this manual serves as a foundational guide rather than an exhaustive list of hazards or solutions. It encourages proactive safety awareness and adaptability when addressing new risks in laboratory settings.

Policy

EHS is committed to:

1. Providing a safe, secure, and healthy environment for faculty, staff, students, and visitors.
2. Collaborating with local, state, and federal regulatory agencies to promote safety and compliance.
3. Ensuring adherence to applicable environmental health and safety laws, regulations, and industry standards.

Guiding Principles

Safety and compliance are shared responsibilities across the University community. Every faculty member, staff employee, student, and visitor plays a role in maintaining a safe environment. This responsibility cannot be transferred or delegated.

The University is dedicated to:

1. **Protecting** the health and safety of faculty, staff, students, visitors, and the surrounding community.
2. **Maintaining** safe academic, research, and administrative workplaces.
3. **Providing** training and information on potential environmental, health, and safety hazards.
4. **Promoting** the adoption of industry best practices for environmental health and safety.
5. **Encouraging** hazard reporting and taking corrective action to address risks.

Scope
The safety principles and practices outlined in this manual apply to all University of Miami research laboratories, including satellite locations and international research stations.

DEFINITIONS

American Conference of Governmental Industrial Hygienists (ACGIH) is a member-based organization that advances occupational and environmental health. The ACGIH publishes the Threshold Limit Values (see below). https://www.acgih.org/

Anhydride – A compound, often an acid, that forms when water molecules (hydrogen and oxygen) are removed.

Anhydrous – Meaning "without water"; refers to a substance that lacks water molecules, either as hydrates or in crystallization.

Asphyxia – A condition caused by oxygen deprivation, leading to unconsciousness or death; also known as suffocation.

Asphyxiant – A substance that induces asphyxia, potentially causing unconsciousness or death due to oxygen displacement.

Autoignition Temperature – The lowest temperature at which a substance spontaneously ignites in normal atmospheric conditions without an external ignition source.

Base – A substance that donates electrons or hydroxide ions or accepts protons. Bases have a pH greater than 7, with examples including calcium carbonate, sodium hydroxide, and sodium carbonate.

Bacille Calmette-Guérin (BCG) – A tuberculosis vaccine used in certain countries with a high prevalence of TB to provide protection against severe forms of the disease.

Biodegradable – The ability of a substance to decompose naturally through bacterial or other biological processes.

Biological Materials – Includes infectious agents, environmental samples, biological derivatives, human and animal cell lines, human samples, recombinant materials, and plants.

Biomedical Waste – Any solid or liquid waste that may pose an infection risk to humans, as defined by the State of Florida. Statue can be found here: Statutes & Constitution :View Statutes : Online Sunshine.

Biomedical Waste Disposal Bags – Commonly referred to as "**Red Bags**", these are the only approved biomedical waste disposal bags at the University of Miami. Other types are not permitted under Florida state regulations.

Bloodborne Pathogens Policy – The University's Exposure Control Plan, designed to eliminate or minimize occupational exposure to bloodborne pathogens

Boiling point (BP) – The temperature at which the vapor pressure of a liquid equals atmospheric pressure, causing the liquid to transition into vapor. Flammable substances with low BP pose unique fire hazards (e.g., butane, BP=31ºF; gasoline, BP=100ºF).

British Thermal Unit (BTU) – The amount of heat required to raise the temperature of 1 pound of water by 1ºF.

Buffer – A substance that stabilizes pH by minimizing changes in hydrogen ion concentration when acids or bases are added.

Carcinogen – A substance capable of causing cancer in humans or animals. A material is classified as a carcinogen if:

1. It has been evaluated and listed by the International Agency for Research on Cancer (IARC).
2. It is included as a known or suspected carcinogen in the Annual Report on Carcinogens by the National Toxicology Program (NTP).
3. It is regulated by OSHA as a carcinogen.
4. It meets EPA criteria as a known or suspected carcinogen.

Chemical Abstract Service (CAS) Registration Number – A unique identifier assigned to a chemical substance by the Chemical Abstract Service (CAS). Each number corresponds to a specific chemical described in scientific literature. CAS numbers can be up to 10 digits long and follow a distinct format: xxxxxxx-yy-z. While CAS numbers provide a reliable way to reference substances, they do not define or describe a chemical's structure.

Combustible – A classification used by NFPA, DOT, and other regulatory agencies for liquids that will burn, based on their flash point.

Corrosive – A substance that causes visible destruction or irreversible damage to living tissue through chemical reaction at the point of contact.

Cryogenic – Pertaining to extremely low temperatures, typically involving refrigerated gases or fluids.

Cylinders in Use – Cylinders are considered "in use" if they:

- Have a regulator attached and are connected to a gas delivery system supplying an instrument that is used at least monthly.
- Maintain a regulator in place to facilitate frequent use (at least weekly).
- Cylinders used less frequently should be disconnected from the gas delivery system when not in use.

Dermal toxicity – Adverse effects resulting from skin contact to a material.

Designated Area – A specific section of a laboratory designed reserved for handling extremely hazardous chemicals or substances requiring special precautions. The area must include appropriate engineering controls (e.g., fume hoods, biosafety cabinets), clear warning labels, and strict access restrictions. A Standard Operating Procedure (SOP), outlining methods, responsible individuals, materials, and handling protocols must be completed by the Principal Investigator (PI) and reviewed by EHS.

Doff – To remove an article of clothing or personal protective equipment (PPE), such as gloves, lab coats, or safety goggles, after completing tasks that require protection.

Don – To put on an article of clothing or personal protective equipment, such as gloves, lab coats, or safety goggles, before engaging in tasks that require protection.

Dry Bench Laboratory (Dry Lab or Instrument Lab) – A lab primarily dedicated to instrumentation, without the elements that characterize a wet bench lab. Examples include computer modeling labs, microscope labs, and NMR rooms.

Emergency Contacts – Individuals responsible for laboratory oversight who must be reachable 24/7 in case of an emergency.

Engineering Controls – Built-in systems or equipment designed to reduce exposure to and protect individuals from laboratory hazards. These include fume hoods, biosafety cabinets, and building ventilation systems.

Environmental Health and Safety (EHS) – The Office responsible for providing occupational and environmental protection services. EHS ensures compliance with regulations and works to prevent occupational diseases, injuries, property loss, and environmental degradation.

Evaporation Rate – The rate at which a substance transitions from liquid or solid to vapor. The rate helps assess the health and fire hazards of a material.

Explosion-Proof Refrigerators – Refrigerators designed with protected internal and external components to safely store flammable materials in environments with flammable atmospheric conditions.

Exposure Limits – Defined thresholds for the maximum concentration of hazardous chemicals to which employees can be exposed over a period of time. These limits help ensure workplace safety and are often set by regulatory agencies.

Flammable – Capable of catching fire and burning easily.

Flammable Gas – A gas that has a flammable range with air at 68ºF and a standard pressure of 101.3 kPa (14.7 psi). Examples include hydrogen, acetylene, and propane.

Flammable-Safe Refrigerators – Refrigerators with protected internal electrical components that eliminate ignition sources, making them safe for storing flammable materials.

Flash point – The lowest temperature at which a liquid has a sufficient vapor pressure to form an ignitable mixture with air near its surface.

Freezing point – The temperature at which a material transitions from liquid to solid.

Hazardous Chemical – A chemical that presents either a physical hazard or a health hazard, including simple asphyxiants, combustible dusts, pyrophoric gases, or other hazards not otherwise classified.

Hazardous Material – Any substance or mixture of that can adversely affect human health or safety. These materials exhibit characteristics of ignitability, corrosivity, reactivity and toxicity, as defined in 40 CFR 261.3 Subpart D, or are listed in 40 CFR 261.31-33.

High Efficiency Particulate Air (HEPA) filter – Air-purifying filter used that removes 99.97% of airborne particles, including dust, pollen, and microorganisms. HEPA filters are used in biosafety cabinets to sterilize the air and prevent contamination.

Immunocompromised – A condition in which the immune system is weakened or absent due to an inherited condition, other disease or medications. Individuals who are immunocompromised have reduced ability to fight infections effectively.

Incompatible Materials – Materials that can cause dangerous reactions when mixed or stored together, posing a risk to health and safety. Common examples include acids and azides, nitrates and sulphuric acid, and sodium and water.

Instructional Laboratory - A laboratory unit used for post-secondary education, operating under the direct supervision of an instructor to facilitate student learning.

Irritant – A non-corrosive material that causes reversible inflammation upon contact with living tissue. The severity of the reaction depends on concentration and exposure duration.

Laboratory – Any space or room where chemicals or biological materials are used on a small, non-production scale for research, experimentation, or instructional purposes.

Lower Explosive Limit (LEL) – The lowest concentration of a flammable vapor in air (by volume) at which combustion can occur when an ignition source is present. Below this limit, the mixture is too lean to ignite.

Lethal Concentration 50 Percent (LC_{50}) – A toxicological measurement representing the concentration of a substance in air that causes death in 50% of test animals within a specified time when inhaled.

Lethal Dose 50 Percent (LD_{50}) – A toxicological measure of a substance's lethal dose, indicating the amount at which 50% of test animals within a set period. The method of exposure (oral, intravenous, intraperitoneal, etc.) is specified in testing

Melting point – The temperature at which a solid transitions to liquid under normal atmospheric pressure.

Mutagen – A substance or agent that induces genetic mutations in DNA, potentially affecting cell function or causing genetic disorders.

Nanoparticles – Microscopic particles ranging in size from 1 to 100 nanometers (nm) in diameter, often possessing unique physical and chemical properties due to their small scale.

Nanotechnology – The manipulation of matter on a near-atomic scale, typically at dimensions smaller than 100 nm. One nanometer is 1 billionth of a meter (10^{-9}m).

National Fire Protection Association (NFPA) – An international nonprofit organization established to reduce fire hazards and improve safety. NFPA develops and publishes over 300 consensus-based codes and standards to minimize related risks. The website is at NFPA | The National Fire Protection Association.

Occupational Safety and Health Administration (OSHA) – A United States federal Agency under the Departement of Labor. OSHA is responsible for setting and enforcing workplace safety and health regulations to protect employees from hazards.

Odor Threshold – The concentration of an odorous gas or vapor at which 50% of a panel of test subjects can detect the smell.

Oxidation – A reaction in which a substance combines with oxygen provided by an oxidizer or oxidizing agent. Also refers to the process of electron removal from atoms or ions.

Oxidizer – A substance that readily releases oxygen, stimulating the combustion (oxidation) of organic matter.

Personal Protective Equipment (PPE) – Protective gear worn to minimize exposure to workplace hazards. Examples include safety glasses, lab coats, aprons, respirators, and gloves. PPE serves as a secondary layer of defense when other safety measures are insufficient or impractical.

Permissible Exposure Limit (PEL) – The maximum allowable concentration of a hazardous substance, set by OSHA (29 CFR 1910.1000), to which workers can be exposed without expected adverse health effects. Typically based on an eight-hour time-weighted average (TWA) over a 40-hour workweek.

pH – A numerical scale representing the acidity or alkalinity of an aqueous solution. Defined as the negative base-10 logarithm of the hydrogen ion concentration: $pH = -\log_{10}[H^+]$, where $[H^+]$ represents the hydrogen ion concentration in the solution.

Physical State – The condition of a material (solid, liquid, or gas) at a specific temperature and pressure.

Post-Exposure Prophylaxis – A preventative medical treatment administered immediately after exposure to a pathogen to reduce the risk of infection.

Primary Container – The original container in which a chemical or chemical product is received.

Pyrophoric Chemical – A substance that spontaneously ignites upon exposure to air or moisture due to non-detonative, self-sustaining exothermic chemical reactions. These chemicals are highly reactive and require specialized handling to prevent unintended ignition.

Reducing Agent – A substance that either:

1. Loses oxygen during a reaction.
2. Gains electrons in an oxidation-reduction process.

Recommended Exposure Limit (REL) – The maximum allowable airborne concentration of a substance set by NIOSH to protect workers. RELs may be expressed as a ceiling limit or as a time-weighted average (typically over an 8-hour work shift).

Resource Conservation and Recovery Act (RCRA) – A U.S. environmental law (42 U.S.C. §6901 et seq., 1976), granting the EPA authority to regulate hazardous waste from "cradle-to-grave" – covering generation, transportation, treatment, storage, and disposal. RCRA also provides a framework non-hazardous solid waste management.

Safety Can – An approved container, usually 5 gallons or less, designed to safely store or transport flammable or hazardous liquids. It features a spring-closing lid and spout cover to relieve internal pressure in case of fire.

Safety Data Sheet (SDS) – A document that chemical manufacturers or distributors are required to produce, describing the hazards associated with a chemical or chemical product. It includes information on safe handling procedures, required personal protective equipment (PPE), and emergency measures. In the U.S., SDSs are mandated by OSHA, under 29 CFR 1910.1200, the Hazard Communication Standard.

Secondary Container – A container used to transfer a chemical or chemical product from its original packaging, or to store a newly prepared chemical or reagent. These containers must be selected based on compatibility with the chemical contents and properly labeled to ensure safe identification and handling.

Secondary Containment – A container or device designed to capture accidental spills or leaks of chemicals or chemical waste, preventing release into the surrounding environment. Examples include chemically resistant trays, bins, or buckets placed beneath primary containers. The containment must be large enough to hold the full volume of the largest container it supports. Some chemical storage cabinets include a built-in lip on the bottom shelf that functions as secondary containment.

Select Agents – A group of federally regulated bacteria, viruses, fungi, and toxins that pose a severe threat to public, animal, or plant health. The possession, use, and transfer of these agents are restricted under the USA PATRIOT Act and the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.

Sensitizer – A substance that may not cause an immediate physiological response upon first exposure but can trigger a significant allergic or hypersensitive reaction after repeated exposures. The skin and respiratory system are the most commonly affected areas.

Sharps – Objects designed for or capable of puncturing, cutting, or otherwise penetrating the skin, such as needles, scalpels, and pipette tips.

Sharps Container – A rigid, leak-proof, and puncture-resistant container specifically designed to safely hold sharps. It must be clearly labeled with one of the approved phrases ("BIOMEDICAL WASTE," "BIOHAZARD") and display the international biological hazard symbol, as required by section 64E-16.004(2)(a), F.A.C. The container must also be manufactured using dyes that meet the incidental metals standards outlined in section 64E-16.004(2)(b)1.b., F.A.C.

Specific Gravity – The ratio of the mass of a substance to the mass of an equal volume of water at 4ºC (or other specified temperature).

Standard Operating Procedure (SOP) – A documented set of instructions detailing the methods, responsible personnel, materials, and procedures for handling hazardous substances in a specific laboratory area. SOPs are required when working with extremely hazardous chemicals or infectious agents.

Standard Precautions – A set of infection control practices that treat all human blood and certain body fluids as potentially infectious for HIV, HBV, and other bloodborne pathogens. Formerly referred to as Universal Precautions.

Target Organ – A specific organ or biological system that is primarily affected by a particular chemical, drug, or toxic.

Tepid Water – Water that is neither hot nor cold, typically referred to as lukewarm. Emergency eyewash stations and safety showers must provide tepid water—a mix of hot and cold—to prevent further injury to individuals exposed to hazardous substances.

Threshold Limit Value (TLV) – A guideline established by the American Conference of Governmental Industrial Hygienists (ACGIH) representing the level of airborne concentration of a substance to which nearly all workers may be repeatedly exposed without adverse effects. TLVs are not legal standards but are widely used in occupational health. They are expressed in three forms:

- **TLV–Time-Weighted Average (TLV–TWA):** Average exposure over a standard 8-hour workday or 40-hour workweek.
- **TLV–Short-Term Exposure Limit (TLV–STEL):** Maximum exposure for a 15-minute period, up to four times per day, without exceeding the TWA.
- **TLV–Ceiling (TLV–C):** Concentration that should not be exceeded at any time.

Toxic – Describes a substance's ability to cause harm or injury to living tissue through chemical action.

Toxic Concentration Low (TCLo) – The lowest concentration of a substance in air that has been reported to cause toxic effects, tumor formation, or reproductive changes in humans or animals during a specified exposure period.

Toxic Gas – A gas that can cause harm or death to living organisms when inhaled, ingested, or absorbed by the skin or eyes. Toxic gases may result from chemical reactions, biological breakdown or industrial processes. Toxicity is commonly measured by the LC_{50} in air.

Tuberculosis (TB) – A contagious disease caused by the bacterium *Mycobacterium tuberculosis*. It primarily affects the lungs but can also impact other parts of the body, such as the kidneys, spine, or brain.

United States Environmental Protection Agency (US EPA) – A federal agency that provides environmental information and enforces laws and regulations to protect human health and the environment. The website can be found here U.S. Environmental Protection Agency | US EPA.

Upper Explosive Limit (UEL) – The highest concentration of a flammable vapor in air (by volume) at which combustion can occur when an ignition source is present. Above this limit, the mixture is too rich to ignite.

Used Oil – Any oil that has been refined from crude oil or is synthetic, and has been used, resulting in contamination by physical or chemical impurities. Examples include motor oil, hydraulic fluids, lubricants, and oil-based coolants.

Vapor Pressure – The pressure exerted by a vapor in equilibrium with its liquid or solid phase at a given temperature. It helps determine how readily a substance can become airborne, influencing potential exposure risks.

Volatility – A measure of how readily a substance vaporizes or evaporates under normal (ambient) conditions.

Water Reactivity – The ability of a substance to react with water, potentially releasing a gas that is flammable, toxic, or otherwise hazardous to health.

Wet Bench Laboratory (Wet Lab) – A laboratory environment where chemicals, biological agents, or radiological materials are used, stored, or manipulated. Activities may include pouring, transferring, pipetting, reacting, incubating, heating, or otherwise handling these substances.

BASIC LAB SAFETY PRINCIPLES

Risk Assessment

Risk assessment is a systematic process performed to identify, analyze, and control hazards and risks present in a laboratory. This process evaluates risk as the product of the probability of an outcome occurring and the severity of its consequences (see Figure 1. Risk Assessment Matrix). Upon evaluation, risk mitigation strategies are adopted to reduce either the likelihood of exposure or the severity of its consequences as much as reasonably practicable until a tolerable residual risk is achieved.

Risk Assessment Matrix				
	Severity			
Probability	Catastrophic - 4	Critical - 3	Marginal - 2	Negligible - 1
Frequent - 4	High (16)	High (12)	Serious (8)	Medium (4)
Probable - 3	High (12)	Serious (9)	Serious (6)	Medium (3)
Remote - 2	Serious (8)	Serious (6)	Medium (4)	Low (2)
Improbable - 1	Medium (4)	Medium (3)	Low (2)	Low (1)

Figure 1. Risk Assessment Matrix

Even after implementing mitigation measures, some level of residual risk typically remains that cannot be mitigated without additional controls or resources that may be excessive or non-existent (Figure 2. Mitigate Risk to a Residual Risk Level). If the remaining residual risk is still considered significant or could lead to a severe exposure that could result in hospitalization or death, the experiment may be deemed infeasible to conduct at the University.

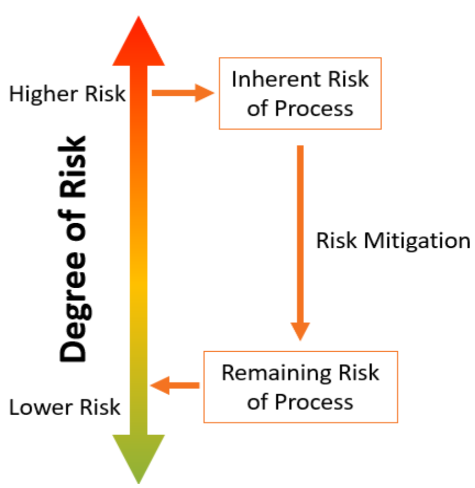

Figure 2. Mitigate Risk to a Residual Risk Level

Hierarchy of Controls & Risk Mitigation

The hierarchy of controls is a method of identifying and ranking safeguards to protect workers from hazards. They are arranged in descending order of effectiveness: elimination of the hazard, substitution, engineering controls, administrative controls, and PPE.

- **Elimination** – Physically remove the hazard.
- **Substitution** – Replace the hazard with a less dangerous one.
- **Engineering Controls** – Isolate people from the hazard (e.g., fume hoods).
- **Administrative Controls** – Change the way people work (e.g., training, SOPs).
- **PPE** – Protect the worker with personal protective equipment.

See Figure 3. Hierarchy of Controls Pyramid for a visual representation of the hierarchy and Figure 4. Hazard Control Level Definitions (OSHA.gov) for accompanying explanations. This hierarchy prioritizes controls that are inherently more reliable and less dependent on individual behavior.

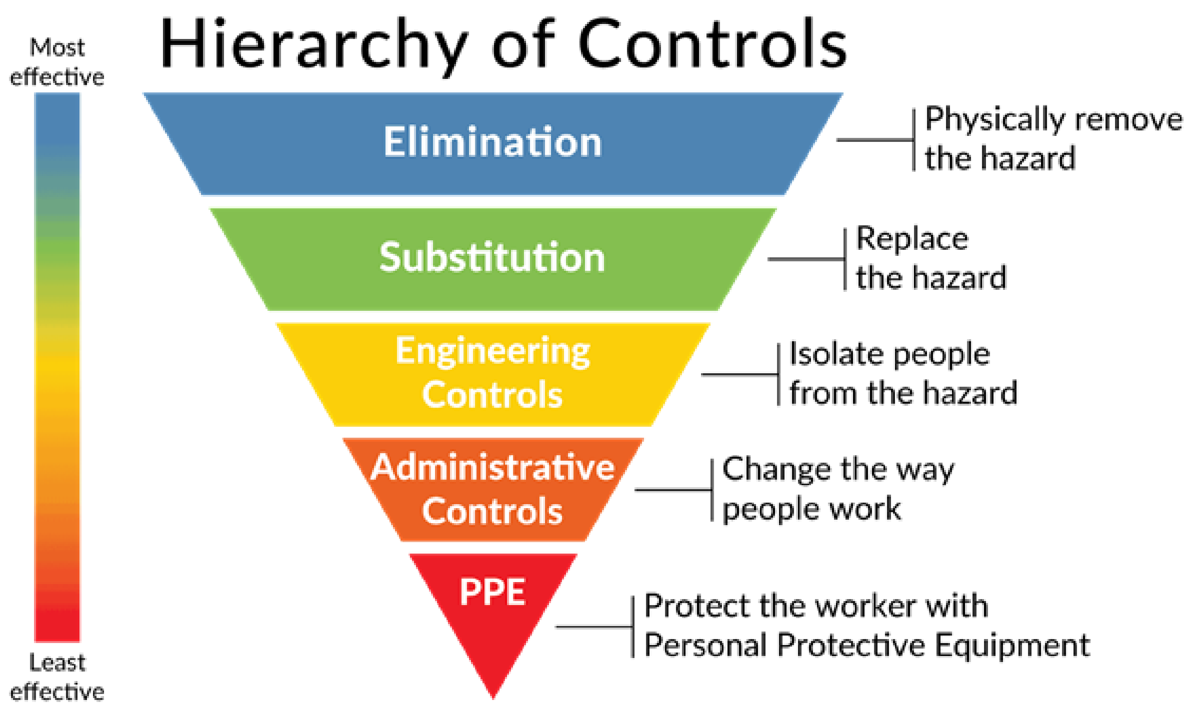

Figure 3. Hierarchy of Controls Pyramid

Elimination

Elimination makes sure the hazard **no longer exists**. Examples:

- Ending the use of a hazardous material
- Doing work at ground level rather than at heights
- Stopping the use of noisy processes

Substitution

Substitution means changing out a **material** or **process** to reduce the hazard. Examples:

- Switching to a less hazardous material
- Switching to a process that uses less force, speed, temperature, or electrical current

Engineering Controls

Engineering controls reduce exposure by **preventing hazards from coming into contact with workers.** They still allow workers to do their jobs, though. Examples:

- Noise enclosures
- Local exhaust ventilation
- Guardrail system
- Machine guards
- Interlocks
- Lift equipment

Administrative Controls

Administrative controls change the way work is done or **give workers more information by providing workers** with relevant procedures, training, or warnings. They're often used together with higher-level controls. They include:

- **Procedures**, such as equipment inspections, planned preventive maintenance, checklists, lockout/tagout/tryout, infection prevention and control practices, changing work schedules, pre- and post-task reviews, and rotation of workers
- **Training** on topics such as hazard communication, permit-required confined space entry, lockout/tagout/tryout, and safe work procedures
- **Warnings,** such as signs, backup alarms, smoke detectors, computer messages, mirrors, horns, labels, and instructions

Personal Protective Equipment

Personal protective equipment (PPE) includes clothing and devices to protect workers PPE needs constant effort and attention (including proper use and training) from workers. Higher-level controls aren't always feasible, and PPE might be needed in conjunction with other control measures. Examples:

- Safety glasses
- Personal Fall Protection Systems and related equipment
- Hardhats
- Respirators
- Hearing protection
- Protective clothing

Figure 4. Hazard Control Level Definitions (OSHA.gov)

Standard Operating Procedures (SOP)

A Standard Operating Procedure (SOP) is an established set of methods that describes how to perform a procedure. When using chemicals or biological agents, the PI shall prepare a written SOP outlining the safety precautions needed when handling a particular agent.

- **Extremely Hazardous Chemicals or Procedures**

  Researchers must submit a written SOP to EHS for review before beginning any work involving extremely hazardous chemicals or procedures.

  Refer to the Chemical Safety section titled *Handling Procedures for Selected Groups of Chemicals* for the list and guidance.

- **Biological Research**

  Labs conducting biological research must complete a Biological Hygiene Plan and submit it along with their biological registration.

  This plan will guide the lab in developing SOPs tailored to the risks associated with the biological agents in use.

An SOP should address, but is not limited to, the following elements:

- Identification of agents or hazard used in the process
- Use of engineering controls
- Use of administrative controls
- Use of personal protective equipment (PPE)
- Equipment inspection procedures
- Description of potentially hazardous procedures
- Access restrictions
- Decontamination procedures
- Waste disposal procedures
- Medical surveillance or personnel monitoring, if required
- Emergency response plan
- Regulatory compliance requirements

Appropriate Lab Attire

All individuals entering the laboratory—regardless of purpose—must wear appropriate clothing to minimize exposure risks. This includes:

- **Full skin coverage from neck to toe**:
  - Long pants that extend to the shoes
  - Shirts that fully cover the torso
  - Closed-toe shoes
- **Prohibited clothing**:
  - Flip flops or open-toed shoes
  - Clothing with holes, rips, or tears
  - Cropped tops
  - Dresses or skirts (unless worn with full leg coverage)

- Any clothing that leaves skin exposed
- **Accessories**:
    - Jewelry must be secured under clothing to prevent exposure.
    - Accessories that interfere with PPE use or pose a hazard must be removed.
- **Hair**:
    - Secure long hair behind the head to prevent accidental contract with hazardous materials or entanglement in equipment.

Personal Protective Equipment (PPE)

PPE is used to protect lab personnel from residual risks that remain after other risk mitigation strategies (elimination, substitution, engineering, and administrative controls) have been applied. As the least effective method in the hierarchy of controls, PPE should never be the sole protective measure.

- **Minimum Required PPE for General Lab Work:**
    - Safety glasses
    - Lab coat
    - Gloves

These items are considered the baseline. Additional PPE may be required depending on the specific hazards and procedures involved.

- **Common Additional PPE:**
    - Chemical goggles
    - Face shields
    - Aprons
    - Earplugs
    - Respirators

Select PPE based on the completed risk assessment, ensuring compatibility with the materials and procedures involved.

Requirement	Notes
Safety glasses or chemical goggles worn in all wet bench and cell culture labs	Prescription glasses are not a substitute for safety glasses
Gloves selected based on chemical resistance	Nitrile is a good general-purpose glove; consult an SDS or vendor table for specific chemicals

Requirement	Notes
Lab coats worn before handling chemicals, biologicals, or radiological sources	Required PPE must be donned before exposure begins
PPE removed before leaving the work area	Exception only when needed to transport hazards between spaces; may require second person for assistance in opening doors or accessing other spaces
Contaminated gloves removed before touching common surfaces	Change out or remove gloves to prevent secondary or cross-contamination

Table 1. PPE Safety Standards Checklist

Respiratory Protection

The primary method for protecting against airborne contaminants in research laboratories is through engineering controls, such as fume hoods. According to OSHA's Respiratory Protection Standard, respirators should only be used when engineering and administrative controls are not feasible.

Before a negative pressure respirator can be issued:

- A need must be established through risk assessment
- The individual must be enrolled in a Respiratory Protection Program, which includes:
  - Completion of a medical questionnaire reviewed by a licensed healthcare professional
  - Training on respirator use
  - Initial and annual fit testing

Using the wrong respirator, one that doesn't fit, or lacking proper training can lead to a false sense of security and potential exposure.

For any work requiring a respirator, a fit testing appointment is mandatory. For scheduling reach out to the EHS Industrial Hygiene team at Contact Us | Environmental Health and Safety | University of Miami. Fit testing includes:

- Training
- Respirator selection assistance
- Instruction on cleaning, storage, and maintenance

General Research Principles

The Principal Investigator (PI) is responsible for ensuring safe working practices in the lab. However, every lab worker must take personal responsibility for following SOPs, specific instructions, and best practices.

Key Principles:

- **Hazard Assessment**
  Before starting new experiments or using new chemicals/procedures, assess potential hazards.

Identify and implement appropriate controls (engineering, administrative, PPE). Develop experiment-specific guidelines.

- **Right to Stop**
  If there is evidence of imminent risk to health, safety, or the environment, stop immediately and consult the lab's responsible person.
- **Implement Controls**
  Apply controls to minimize exposure to hazards. Use the hierarchy of controls to guide decisions.
- **Avoid Risk Underestimation**
  Minimize exposure even to substances with no known hazard. Treat unknown substances as potentially toxic. Use special precautions for particularly hazardous substances.
- **Follow Administrative Controls**
  Adhere to regulations, SOPs, manuals, guides, and best practices.

General Safety Standards for All Labs

- Keep work areas clean, organized, and uncluttered.
- Do not store items in hallways or block emergency exits and equipment.
- Avoid working alone. If necessary, ensure periodic check-ins with lab personnel or campus security (e.g., UMPD for Coral Gables).
- No food, drink, gum, makeup, or contact lens handling in lab areas.
- Be familiar with safety equipment (fire extinguishers, eyewash stations, spill kits, etc.).
- Post hazard signage and ensure all hazards are clearly marked.
- Restrict access to authorized personnel only. Keep lab doors closed and post relevant warning signs.
- All University of Miami employees must be informed of workplace hazards. Visit Environmental Health and Safety | University of Miami for safety resources, SDS inventory, and more.

Safety Training

EHS provides safety training through digital, on-demand platforms and in-person sessions upon request or special event. Training requirements are determined by the types of hazards and work performed in the laboratory.

Required safety training must be completed before an employee is begins laboratory duties.

EHS Training Courses

EHS offers a variety of safety training courses. For a current list of available trainings, please visit the EHS website training page at Training | Environmental Health and Safety | University of Miami. The list below provides a brief overview of key training offerings. For personalized guidance or to request a session, please contact EHS utilizing the EHS Contact Page.

Laboratory Safety Training – Required every 5 years
This training provides foundational knowledge on general laboratory safety practices. It covers the risk assessment process for handling hazardous chemicals, proper disposal of chemical waste, laboratory ventilation systems, use of chemical spill kits, and appropriate personal protective equipment (PPE).

Participants will also gain an understanding of compliance requirements with applicable regulations, standards, and institutional guidelines.

This training is mandatory for faculty, students, and staff working in academic or research laboratories.
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General Biosafety Training – Required every 3 years
This training introduces the risk assessment process for biological research and outlines risk mitigation strategies specific to biological laboratories. It covers the application of engineering controls, work practice controls, personal protective equipment (PPE), and administrative controls within the context of research conducted at the University of Miami.

Completion of this training is mandatory for laboratory personnel working with biological materials.

OSHA Bloodborne Pathogens, Tuberculosis, Latex Allergy, and Biomedical Waste Training – Required Annually
This training provides essential information on the transmission of bloodborne pathogens and methods for preventing infection. It also outlines procedures for post-exposure medical evaluation.
This course is mandatory for all individuals with potential occupational exposure to:

- Human blood or most human body fluids
- Unfixed human tissue
- Laboratory or animal materials contaminated with HIV or HBV

Shipping of Dangerous Goods Training – Required every 2 years
This training introduces the regulations and requirements for shipping hazardous materials, as outlined by:

- The International Air Transport Association (IATA) Dangerous Goods Regulations
- The U.S. Department of Transportation (DOT)

It is required for all employees involved in the shipment of hazardous materials, including but not limited to chemicals, paints, batteries, and biologicals.

Shipping of Biological Materials Training
This course provides detailed guidance on the proper packaging, labeling, and shipment of biological materials and commonly used preservatives.
It is required for anyone involved in shipping biological materials and must be completed in addition to the Shipping of Dangerous Goods training.

Fire Safety Training
This session provides a foundational understanding of general fire hazards, safety precautions, and evacuation procedures. It also includes instruction on the proper use of fire extinguishers.
Practical fire extinguisher training is available upon request.

Respiratory Protection Training
This training is designed for individuals who may be exposed to respiratory hazards such as harmful dusts, fibers, biological agents, fumes, mists, gases, smokes, sprays, or vapors. It emphasizes minimizing exposure through:

- **Engineering controls** (e.g., enclosures, exhaust ventilation)
- **Administrative controls** (e.g., substitution of less hazardous materials)

When these controls are not feasible or are being implemented, appropriate respirators must be used in accordance with the respiratory protection program. The training includes:

- Respirator selection
- Proper use and maintenance

- Health risks associated with aerosol transmissible diseases (ATDs) such as tuberculosis, measles, and COVID-19

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Basic Laser Safety Training – Required Every 3 Years (for Class 3R, 3B, and 4 Lasers)
This training meets the requirements of ANSI Z136.1 and is mandatory for all laser operators, observers, and personnel working with Class 3R, 3B, and 4 lasers. It is also recommended for those working with Class 1, 1M, 2, and 2M lasers.
Topics include:

- Fundamentals of laser operation
- Bioeffects of laser radiation on eyes and skin
- Specular and diffuse reflections
- Non-beam hazards
- Laser classifications
- Control measures
- Responsibilities of management and employees
- Medical examination practices

Refresher training is required every three years for those working with Class 3R, 3B, and 4 lasers.
Satellite Accumulation Area (SAA) Training
This training covers the fundamentals of hazardous waste management and disposal in compliance with federal, state, and local regulations. Topics include:

- Identifying and designating an SAA location within your lab
- Proper labeling and segregation of hazardous waste
- Disposal procedures
- Spill response protocols

This training is required for all faculty, students, and staff working in academic or research laboratories. To schedule this training, contact EHS Hazmat. Contact information can be found at Contact Us | Environmental Health and Safety | University of Miami.

Biomedical Waste Training – Required Annually
This training provides essential guidance on managing biomedical waste generated in laboratories. Topics include:

- Setting up compliant biomedical waste receptacles
- Identifying and using approved biomedical waste bags
- Proper sealing, labeling, and disposal of waste

This training is mandatory for all faculty, students, and staff working in academic or research laboratories that generate biomedical waste. To schedule this training, contact EHS Hazmat. Contact information can be found at Contact Us | Environmental Health and Safety | University of Miami.

Laboratory Specific Training

Because laboratory hazards can vary significantly, each lab is responsible for providing additional training tailored to its specific risks and procedures. The **Principal Investigator (PI)** holds primary responsibility for ensuring that all personnel are trained on the procedures and safety protocols relevant to their work.

Laboratory-specific training should address the unique hazards and operational practices of the lab. Key topics may include:

- Identification of specific hazards present in the lab, how to interpret labeling information, and safe storage practices
- Emergency response procedures and the location of emergency equipment (e.g., eyewash stations, safety showers)

- Location of fire exits, pull stations, and fire extinguishers
- Required PPE for the lab, including donning and doffing procedures and lab-specific standards
- Safe operation of lab equipment, including chemical fume hoods, biological safety cabinets, and other high-risk devices
- Hazardous waste handling procedures and designated waste storage locations

Commissioning and Decommissioning of Laboratory Space

The PI is responsible for ensuring that all safety, compliance, and operational requirements are met when a laboratory space is either opened (commissioned) or closed (decommissioned). This includes coordination with EHS and other relevant departments.

Commissioning a Lab

When a new laboratory is being established, it is ideal for the PI to meet with EHS personnel early in the process. At a minimum, this meeting should include the Biosafety Officer, Chemical Hygienist, and Hazmat Manager. Early engagement ensures the lab is appropriately equipped and configured for its intended research activities, and that any necessary accommodations can be arranged.

Pre-Work Requirements for Commissioning a Lab:

- **Chemical Management**:
  - Unpack and store chemicals and reagents in their designated storage locations.
  - Create and submit a chemical inventory using the EHS Chemical Inventory Template.
- **Signage and Communication**:
  - Post Lab Safety Information & Emergency Contact Cards to display emergency contacts and identify hazards.
  - Install appropriate safety signage throughout the lab.
- **Biological Safety**:
  - Certify biosafety cabinets and laminar flow hoods if working with biological materials.
- **Protocol Approvals**:
  - Submit research protocols to the appropriate oversight committees (e.g., IBC, IACUC, IRB).
  - Obtain approval before acquiring related materials.
- **Hazardous Waste Management**:
  - Establish a Satellite Accumulation Area (SAA) in the lab. EHS Hazmat can assist with setup.
- **Lab Registration**:
  - Complete and maintain the lab profile in the University's safety platform, SciSure (formerly BioRAFT).
- **Personnel Training and Health**:
  - Ensure lab personnel:
    - Complete safety training relevant to their work
    - Enroll in the Occupational Health Program
    - Are familiar with lab-specific SOPs and approved protocols

Decommissioning

When planning to relocate within or depart from the University of Miami, the PI must notify EHS in advance. Early notification ensures sufficient time for all required decommissioning procedures to be completed. EHS will provide support throughout the lab move process.

Key Responsibilities for Lab Decommissioning:

Inventory Management

- Review and update the chemical inventory.
- Dispose of unwanted or expired hazardous materials (chemicals, biologicals, radioactive sources).
    - This includes legacy samples left by previous occupants.
    - Make reasonable efforts to identify unlabeled or unknown substances.
- If relocating off-campus, consider shipping materials to the new location (requires proper training and coordination with EHS).
- Controlled substances:
    - Return to the Division of Veterinary Resources (DVR) if applicable.
    - If under a personal DEA license, contact the DEA for disposal guidance.

Moving Freezers

- Remove all contents and defrost -80°C and -20°C freezers.
- Clean and disinfect interiors, especially if biological samples were stored.
- If transporting freezers with biological contents:
    - Wipe down the exterior.
    - Notify EHS Biosafety.
    - Tape the unit closed in the presence of EHS Biosafety to prevent accidental opening.
- Do not transport hazardous chemicals or radioactive materials inside freezers.

Moving Biosafety Cabinets

- Must be decontaminated by a certified professional.
- Tape shut in the presence of EHS Biosafety before removal.
- Must be recertified at the new location before reuse.

Gas Cylinders

- Return all gas cylinders to their respective vendors or owners.

Research Protocols

- Notify oversight committees (e.g., IBC, IACUC) of protocol discontinuation or transfer to another faculty member.

Internal Relocation (Within UM)

- Update lab space details in SciSure (formerly BioRAFT).
- Submit a request to EHS to revise building and room numbers in the lab profile.

CHEMICAL SAFETY

Chemical safety involves identifying, communicating, understanding, and managing chemical hazards. The first step in managing these hazards is to assess the risks associated with the chemicals and laboratory operations.

Assessment Steps:

1. **Review the Laboratory Chemical Inventory**
   Researchers must understand the types of chemical hazards to effectively evaluate the chemicals present in their laboratory.
2. **Identify and Research the Chemical in Use**
   Review the chemical's label, Safety Data Sheet, and any other relevant documentation to understand its properties and associated risks.
3. **Evaluate Laboratory Procedures and Risks**
   Consider how the chemical will be used, including potential reactions, storage requirements, and segregation needs. Assess the risks introduced by these operations.
4. **Apply the Hierarchy of Controls to Reduce Risk**
   Implement control measures to minimize risks from hazardous chemicals, their interactions, and related research operations. The goal is to reduce risk to a residual and acceptable level.

   Examples of adequate controls as they apply to chemical usage include:

Control Applied to Chemical Safety	**Description**
Eliminate the hazardous chemical	Redesign the experiment to avoid using the chemical
Substitute with a safer chemical	Use NOTOXhisto instead of Formaldehyde
Isolate or ventilate hazardous chemicals	Use chemical fume hoods, snorkels, or gas cabinets
Define safe procedures or limits	Set restrictions on concentration or quantity
Use PPE as recommended in the SDS	Wear chemical-resistant gloves and safety goggles

These control measures must be in place before initiating any operation with hazardous chemicals.

Chemical Hazards and the Globally Harmonized Systems

Understanding chemical hazards and the systems used to identify them is essential for maintaining a safe and compliant workplace. With the full adoption of the Globally Harmonized System (GHS) in the United States, organizations are required to follow standardized protocols for classifying and communicating chemical risks. This system enhances clarity and consistency in hazard identification, helping employees recognize and respond to both physical and health-related dangers. By integrating GHS principles into daily operations, employers can better protect workers, reduce incidents, and ensure regulatory compliance.

The GHS differs from the UN-DOT system, which focuses on hazardous goods transport.

The two main chemical hazard groups, health hazards and physical hazards, are described as follows:

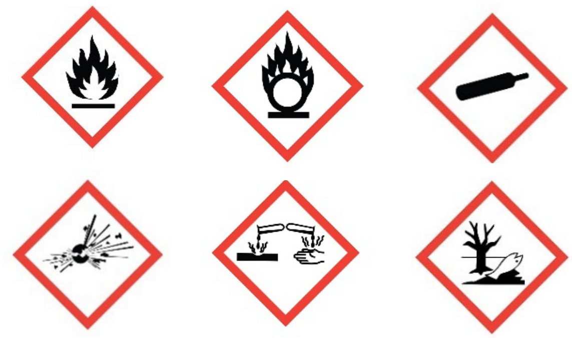
A ***health hazard*** is defined as a chemical that can pose one of the following hazardous effects:

- acute toxicity (any route of exposure)

- skin corrosion or irritation
- serious eye damage or eye irritation
- respiratory or skin sensitization
- mutagenicity
- carcinogenicity
- reproductive toxicity
- specific target organ toxicity (single or repeated exposure)
- aspiration hazard

A ***physical hazard*** is defined as a chemical that can cause serious physical damage or death through skin or eye contact, including but not limited to:

- explosive
- flammable (gases, aerosols, liquids, or solids)
- oxidizer (liquid, solid or gas)
- self-reactive
- pyrophoric (liquid or solid)
- self-heating
- organic peroxide
- corrosive to metal
- gas under pressure
- in contact with water emits flammable gas



Secondary Hazard Identification

Assessing the primary hazard of a chemical is necessary for maintaining safety. It is also important to consider subsidiary hazards, which may create risks under specific circumstances. The GHS adopted by OSHA encourages a thorough approach to chemical safety, acknowledging that a substance may present multiple hazards requiring management. Addressing both primary and subsidiary hazards enables the implementation of appropriate safety protocols.

Chemical Inventory

Laboratories are required to maintain an up-to-date chemical inventory (CI) that records all chemicals on site along with their associated hazards. The chemical inventory can be managed by any laboratory member, but responsibility for its maintenance and updates rests with the Principal Investigator (PI).

The CI should be updated regularly, submitted to EHS, and provided during annual EHS safety inspections. All chemicals—new, used, or listed under other regulatory categories—must be included. Before updating, it’s recommended to dispose of expired, unused, damaged, or contaminated chemicals. This process complies with OSHA standards 1910.1200(e)(1)(i) and 1910.1200(h)(2)(iii).

Labeling

Proper labeling of hazardous chemicals is a cornerstone of workplace safety and regulatory compliance. Under OSHA's Hazard Communication Standard (29 CFR 1910.1200, Appendix C), which aligns with the GHS, chemical labels must follow a standardized format to ensure clear communication of potential risks. Labels serve as the first line of defense in hazard recognition, providing essential information that must match the corresponding SDS. Whether chemicals remain in their original containers or are transferred to secondary ones, accurate and compliant labeling helps prevent exposure incidents and supports informed decision-making by personnel.

Checking the label of a hazardous chemical is essential for hazard recognition. The container's label should match the safety data sheet (SDS). Chemicals must keep their original labels; if moved to another container, they need proper labeling per GHS standards.

- *Product identifier:* Usually the IUPAC name but may also be a trade or common name; the CAS Registry Number is typically included. The label identifier must match that in the SDS (Section 1).
- *Supplier identification:* Name, address, and phone number of the manufacturer, importer, or responsible party.
- *Precautionary statement:* Additional precautionary information intended to lower the risk of exposure.
- *Hazard pictograms:* Indicates hazard class; prioritized in order of concern.
- *Signal word:* A chemical might have multiple hazards; the most significant hazard will be represented on the label with a signal word.
- *Hazard statement:* Summarizes the chemical's hazard. Required when the signal word "Danger" is used.
- *Supplemental info:* Rarely used; provides extra details about the chemical product.

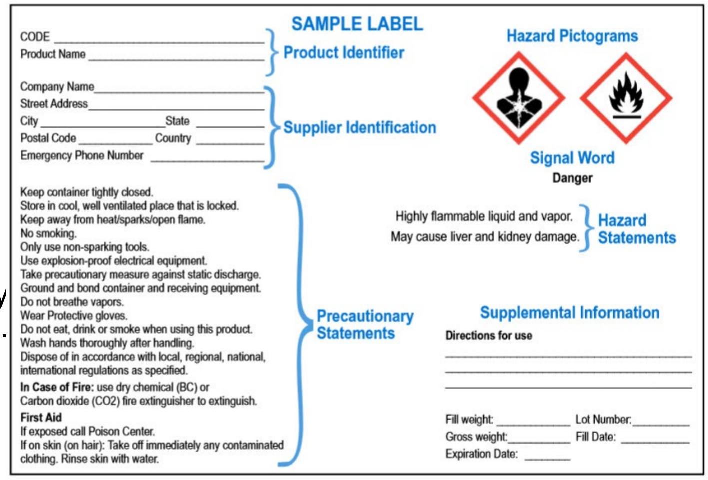


Figure 5. OSHA Hazard Communication Standard Label -Quick Card. Link: [Hazard Communication Standard Labels (osha.gov)]

Precautionary Statement and Code

Precautionary statements describe recommended actions to prevent or reduce adverse effects from exposure, improper storage, or mishandling.

There are **five types** of precautionary statements:

1. **General** – Broad safety guidance.
2. **Prevention** – Measures to minimize exposure.
3. **Response** – Emergency actions, including spill response and first aid.
4. **Storage** – Safe storage practices.
5. **Disposal** – Proper disposal methods.

Statements are **independent**, meaning each stands alone in its guidance. However, OSHA allows flexibility in how these are applied. Precautionary statements can be combined for clarity, ordered to prioritize critical information, and statements can be omitted if justified by the manufacturer or importer.

Precautionary statements are most often represented on labels with an alphanumeric code, beginning with a "P" for "precaution". The first digit represents the type (see above). The next two digits represent the specific statement. Below are some examples of precautionary statements with their corresponding codes.

Precautionary	Statement	Codes and Examples
Code	**Type**	**Statement**
P101	**General**	**If medical advice is needed, have product container or label at hand.**
P202	**Prevention**	**Do not handle until all safety precautions have been read and understood.**
P301+P310	**Response**	**IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.**
P403+P233	**Storage**	**Store in a well-ventilated place. Keep container tightly closed.**
P501	**Disposal**	**Dispose of contents/container in accordance with local/regional/national/international regulations.**

Signal Words

There are only two words used as a **signal word** for hazardous chemicals, **danger** and w**arning.**

- **Danger** – Indicates more severe hazards.
- **Warning** – Indicates less severe hazards.

Each chemical label will use the signal word that corresponds to its **most serious hazard**.

Hazard Statements and Code

Hazard Statements are standardized phrases that describe the nature and severity of chemical hazards. All applicable hazard statements must appear on the label. They may be combined to reduce redundancy and improve readability. The same hazard must be described using the same statement, ensuring consistency across products and manufacturers.

There are **three types** of hazard statements:

1. **Physical Hazards** – represented by the number "2"
2. **Health Hazards** – represented by the number "3"
3. **Environmental Hazards** – represented by the number "4"

Hazard statements are represented on labels with an alphanumeric code, beginning with an "H" for "hazard". The first digit represents the type (see above). The next two digits represent the specific statement. Below are some examples of hazard statements with their corresponding codes.

Code	Hazard Type	Statement
H200	Physical – Explosives	Unstable explosive.
H220	Physical – Flammables	Extremely flammable gas.
H300	Health – Acute Toxicity	Fatal if swallowed.

Code	Hazard Type	Statement
H315	Health – Skin Irritation	Causes skin irritation.
H400	Environmental – Aquatic	Very toxic to aquatic life.
H410	Environmental – Chronic	Very toxic to aquatic life with long lasting effects.

Table 2. Examples of Coded Hazard Statements by Type

The image below depicts various chemicals on campus, each bearing manufacturer labels compliant with regulations. Key label details and their standard positions are indicated in the photograph.

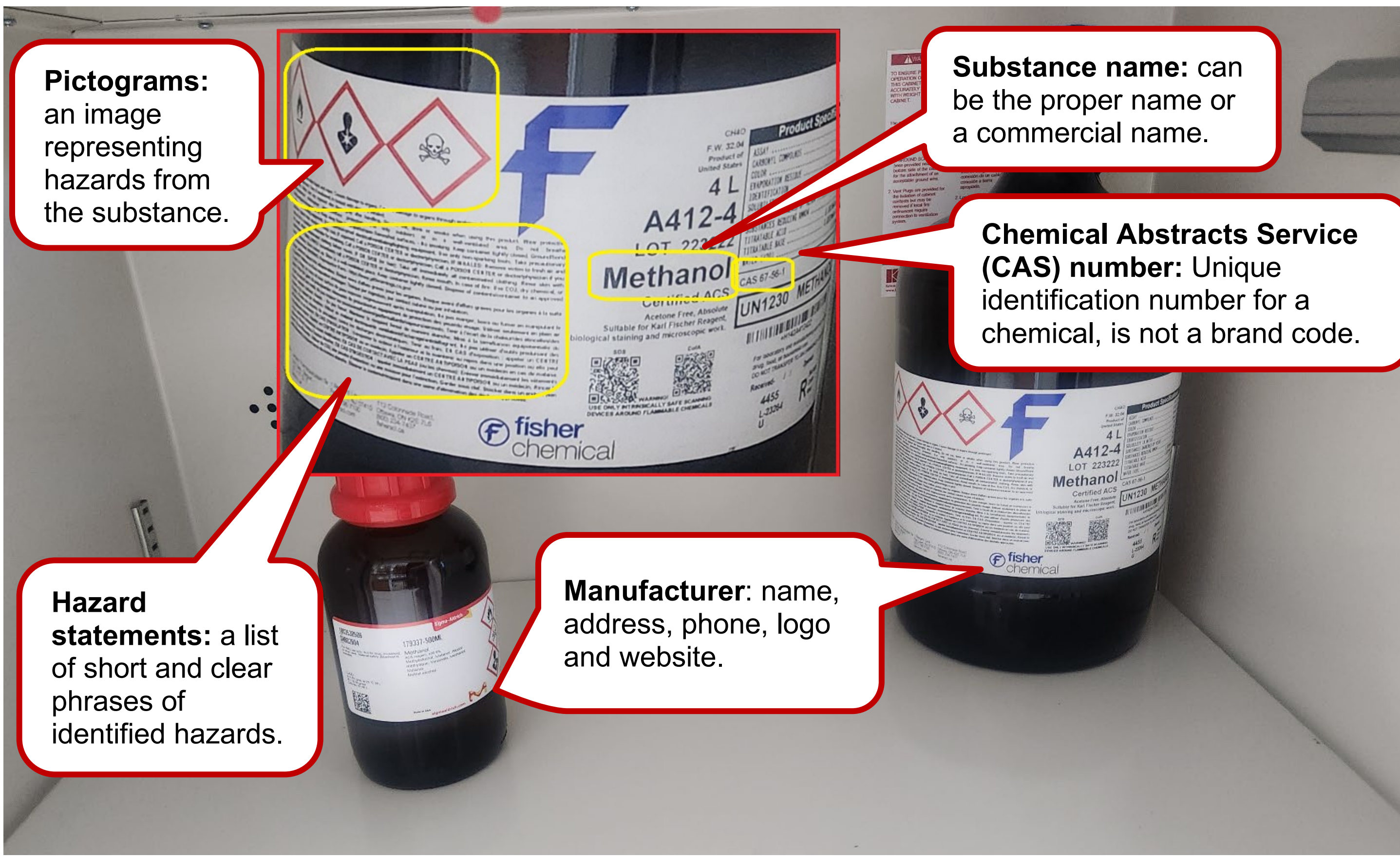


Figure 6. Manufacturer label that meets compliance requirements and indicates where essential information is located.

Workplace Containers and Labels

Keep chemicals in their original GHS-labeled containers whenever possible. If transferring to a new container, label it with the chemical name, constituent(s), preparation date, preparer's initials, and other relevant details. This labeling requirement includes dilutions and stock solutions and be on any temporary vessels, beakers, vials, flasks, etc. Replace any damaged, faded, or otherwise illegible labels. Secondary labels must include:

- Proper chemical name (formula alone is unacceptable)
- Preparer's name
- Date of preparation
- Concentration/composition
- Signal word (if applicable)
- Precaution and hazard statements, if a signal word is used
- Relevant hazard pictograms
- Completed NFPA Diamond

Figure 7. First picture shows two bottles with incomplete labels. Second picture shows labeling updated from NFPA 704 to the GHS label.

Below is a template for an acceptable secondary container label:

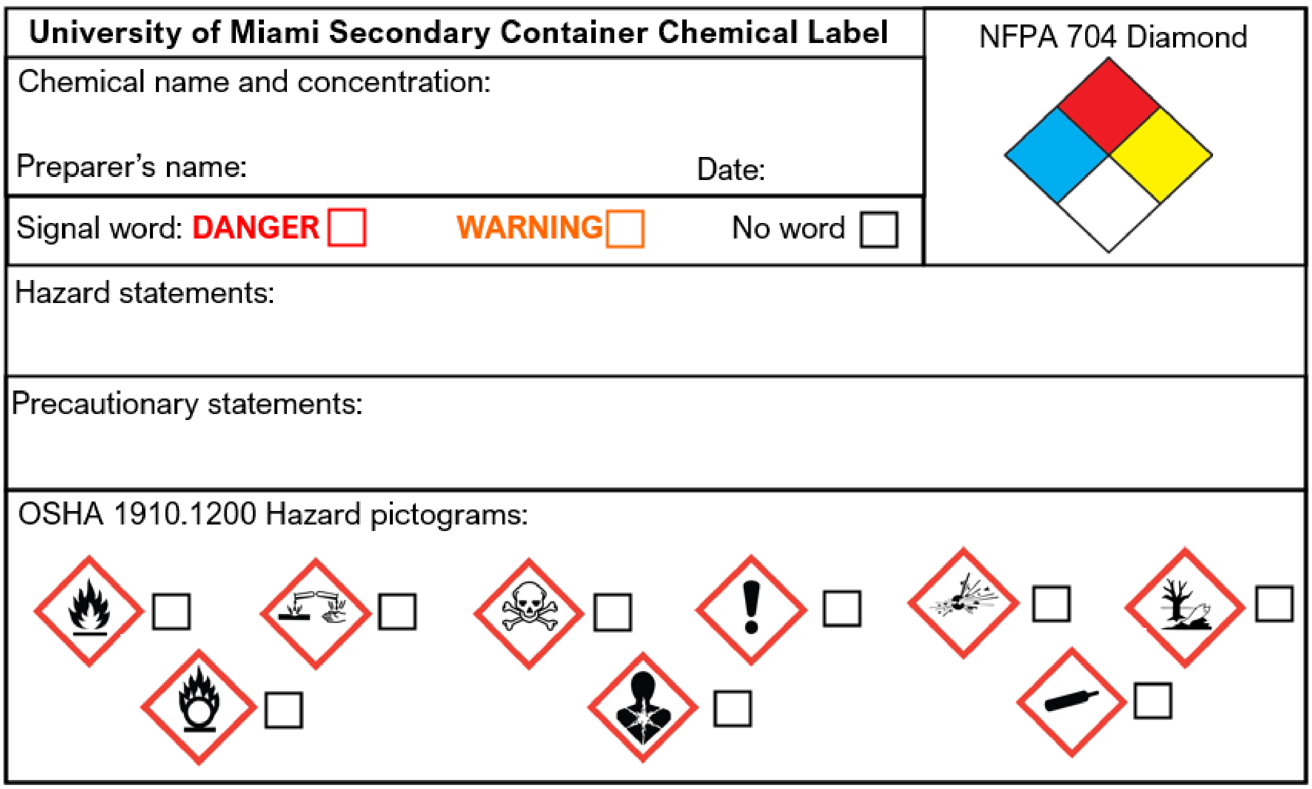


Figure 8: University of Miami secondary container label, 2024.

Safety Data Sheet

A safety data sheet (SDS) is a standardized document required by OSHA and aligned with the GHS. It relays critical hazard information about chemicals.

Each SDS includes details such as chemical properties, physical and health hazards, environmental risks, protective measures, and safety precautions for handling, storing, and transporting chemicals. Principal Investigators (PIs) are responsible for training lab personnel on how to access SDSs and understand chemical hazards. SDSs must be available for all chemicals in the laboratory, either in physical or digital format.

The SDS contains 16 sections:

Section 1 *Identification.* Includes product identifier; manufacturer/distributor name, address, and phone number; emergency contact; recommended use; and usage restrictions.
Section 2 *Hazard(s) identification.* Lists chemical hazards and required label elements.
Section 3 *Composition.* Details ingredient names, percentages (if applicable), and trade secret claims.
Section 4 *First-aid measures.* Describes emergency procedures, symptoms/effects (acute and delayed), and recommended treatments.
Section 5 *Fire-fighting measures.* Specifies suitable extinguishing methods, equipment; fire-related chemical hazards.
Section 6 *Accidental release measures.* Outlines emergency procedures, protective equipment; and cleanup methods.
Section 7 *Handling and storage.* Provides precautions for safe handling and storage, including incompatibilities.
Section 8 *Exposure controls/personal protection.* Lists OSHA's Permissible Exposure Limits (PELs), ACGIH Threshold Limit Values (TLVs), and other exposure limits; includes recommended engineering controls and PPE.
Section 9 *Physical and chemical properties*. Includes:

- Appearance (physical state, color, etc.)
- Odor and odor threshold
- pH, vapor pressure/density
- Melting point/freezing point
- Boiling point/range
- Evaporation rate
- Flash point, auto-ignition temperature
- Upper/lower flammability or explosive limits
- Decomposition temperature
- Solubility
- Partition coefficient: n-octanol/water
- Viscosity

Section 10 *Stability and reactivity.* Describes chemical stability, potential hazardous reactions, stabilizers, and safety concerns related to physical changes.
Section 11 *Toxicological information.* Covers exposures routes (inhalation, ingestion, injection, skin/eye contact), effect (acture/chronic), symptoms, and toxicity measures (e.g., LD50).
Section 12 *Ecological information.* Provides data relating to environmental impacts if the chemical is released.
Section 13 *Disposal considerations.* Provides guidance on disposal, recycling or reclamation.
Section 14 *Transport information.* Provides guidance on classification information for shipping and transportation by road, air, rail, or sea. May include:

- UN number and proper shipping name
- Hazard class
- Packing group number, if applicable
- Environmental hazards (e.g., marine pollutant)
- Bulk transportation guidance

• Any special precautions for transport

Section 15 *Regulatory information.* Lists applicable national/regional regulations (e.g. OSHA, DOT, EPA, CPSC).

Section 16 *Other information.* States the SDS preparation/revision date and highlights changes from previous versions. May include other useful information here.

Aging Hazardous Chemicals

Below are five recommendations for effectively managing the lifespan of chemicals within your inventory:

Appearance and Integrity: If chemicals display signs of contamination or degradation, exhibit diminished chemical integrity, or develop new properties such as crust formation or crystallization, they should be properly discarded. This applies to substances with restricted shelf lives, particularly those susceptible to peroxide formation or spontaneous polymerization. Additionally, if moisture-absorbing chemicals have absorbed water or their containers lack a proper seal, disposal is warranted. Containers showing bulging, collapsing, or corrosion further indicate the necessity for transfer to a Hazmat team.

Expiration Dates: Every chemical should be assigned an expiration date. Disposal is required once this date has passed. For chemicals lacking an expiration date or where the date is illegible, consult the supplier for guidance. The supplier may provide a recommended expiration date, which should then be documented accordingly. Should the supplier recommend disposal, it is best practice to adhere to their advice.

Five-Year Rule: In the absence of an expiration date, many suppliers propose discarding chemicals after five years due to gradual deterioration.

Unused Chemicals: Retaining unused chemicals is common; however, best practice dictates removal of items that are no longer in use. Clearing unused chemicals increases available space and enhances safety.

Research Leftovers: Laboratories frequently accumulate chemicals, equipment, or supplies left by previous occupants. If these materials are seldom or never utilized, reevaluation of their continued storage is advised. In most cases, appropriate disposal is recommended.

In summary, careful consideration should be given to chemical retention in the laboratory environment.

Examples of Chemicals that are Outdated or in Poor Condition:

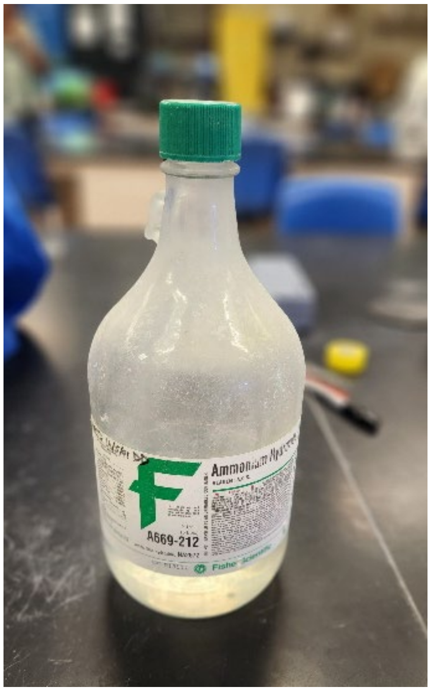


Figure 11: Bottle with evident deposition.

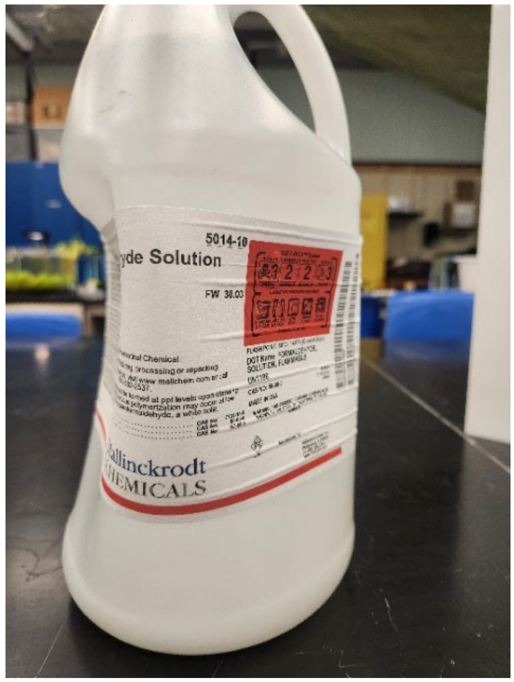


Figure 12: Container deformation in an expired chemical.

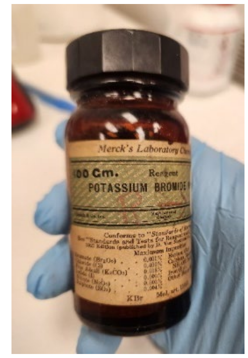


Figure 9: Legacy chemicals, design of label older than OSHA-GHS standard (2016).

Figure 10: Bottle with crystal formation around the neck.

Handling Procedures

When managing commonly used chemical groups, it is essential to implement additional safety procedures. It should be noted that not all chemicals within a group possess identical properties.

Flammables

Flammable and combustible chemicals represent one of the most prevalent hazards in laboratory environments. The risk of fire must always be considered during laboratory operations. To mitigate this risk, all laboratory personnel are expected to understand the properties of the chemicals they handle and recognize how these properties may change under varying laboratory conditions. Safety Data Sheets (SDSs) or equivalent sources should be referenced for critical information, including vapor pressure, flash point, and explosive limits in air.

Flammable liquids produce vapors that can easily ignite and combust when exposed to air. The generation rate of these vapors varies according to each liquid's vapor pressure and temperature. These substances should be handled away from open flames, heat sources, and sparks. Furthermore, flammable liquids must be stored separately from oxidizing agents and corrosive materials, preferably in a designated flammable storage cabinet when available in the work area.

Table 3: NFPA and International Building Code (IBC) classify flammable and combustible liquids based on flashpoint and boiling point.[1]

Type	Class	Flashpoint	Boiling Point
Flammable	IA	<73°F	<100°F
	IB	<73°F	>100°F
	IC	≥73°F and <100°F	
Combustible	II	≥100°F and <140°F	
	IIIA	≥140°F and <200°F	
	IIIB	≥200°F	

Flammable and combustible liquids are classified by OSHA-GHS and labelled accordingly, but all laboratory members should know how to properly manage these classifications. The NFPA diamond rates hazards from 0 (lowest) to 4 (highest), while GHS uses 4 to 1, with 1 as the highest hazard. Unlike NFPA, GHS does not use combustible II and IIIA categories, instead expanding flammables to categories 3 and 4.
The following table compares both classification systems, highlighting their similarities and differences.

Table 4: NFPA 30, GHS, and NFPA 704 flammable and combustible liquids classification and description

NFPA Class	NFPA Description	GHS Category	GHS Description	NFPA 704 Flammability Rating	NFPA 704 Description
Flammable Class IA	Flash Point: Below 73°F (23°C) and Boiling Point: Below 100°F (38°C)	**Flammable Category 1**	Flash Point: Below 73.4°F (23°C) and Initial Boiling Point: ≤ 95°F (35°C)	**4**	Will flash readily or produce flammable gases
Flammable Class IB	Flash Point: Below 73°F (23°C) and Boiling Point: At or above 100°F (38°C)	**Flammable Category 2**	Flash Point: Below 73.4°F (23°C) and initial Boiling Point: > 95°F (35°C)	**3**	Can be ignited under almost all ambient temperature conditions
Flammable Class IC	Flash Point: At or above 73°F (23°C) and below 100°F (38°C)	**Flammable Category 3**	Flash Point: At or above 73.4°F (23°C) and at or below 140°F (60°C)	**3**	Must be moderately heated or exposed to relatively high ambient temperature before ignition can occur

Combustible Class II	Flash Point: At or above 100°F (38°C) and below 140°F (60°C)	**Flammable Category 3**	Flash Point: At or above 73.4°F (23°C) and at or below 140°F (60°C)	**2**	Must be preheated before ignition can occur
Combustible Class IIIA	Flash Point: At or above 140°F (60°C) and below 200°F (93°C)	**Flammable Category 4**	Flash Point: Above 60°C (140°F) and at or below 93°C (200°F)	**2**	Must be preheated before ignition can occur
Combustible Class IIIB	Flash Point: At or above 200°F (93°C)	**Not Flammable**	-	**1**	Must be considerable preheated before ignition can occur

Storage of flammable liquids (including waste) outside approved flammable storage cabinets and safety cans must not exceed 10 gallons per 100 square feet of laboratory space.

<u>Flammable Cabinets:</u> Flammable liquid storage cabinets are designed to safeguard their contents from external fires. These cabinets typically include vents, which are shipped closed by the manufacturer. Current codes do not require venting and the use of open vents may decrease the protective capability of the cabinet. As a result, vents should remain closed. Storage cabinets must display a clear label stating "**FLAMMABLE – KEEP FIRE AWAY**". Flammable storage units are required to be UL listed.

Figure 13. Example of flammable-proof refrigerator (VWR). [VWR® Plus Series Flammable Storage Undercounter Refrigerators | VWR]

<u>Flammable-Proof Refrigerators:</u> Use only those refrigerators that have been designed and manufactured for flammable liquid storage. Standard household or regular laboratory refrigerators must not be used for flammable storage. Refrigerators must be prominently labeled as to whether they are suitable for flammable liquid storage. If not, they shall be clearly labeled as **"NOT FOR FLAMMABLES**".

Flammable and explosion-proof refrigerators are used to safely store volatile materials at low temperatures. Explosion-proof models feature both spark-free interiors and exteriors to prevent ignition from flammable vapors or gases, while flammable material storage units ensure there are no exposed ignition sources inside the cabinet, such as lights or switches.

The following guidelines also apply to the storage of flammable and combustible liquids in laboratory environments:

- Use only flammable approved containers that have been constructed and tested in accordance with UL 1275, Flammable Liquid Storage Cabinets; FM 6050, Approval Standard for Storage Cabinets for Ignitable (Flammable Liquids); or equivalent are considered acceptable.
- Storage cabinets designed and constructed to limit the internal temperature at the center of the cabinet and 1 in. (25 mm) from the top of the cabinet to not more than 325°F (163°C), when subjected to a 10-minute fire test that simulates the fire exposure of the standard time-temperature curve specified in ASTM E119, Fire Tests of Building Construction and Materials, shall be acceptable.
- No more than 10 gallons of flammable and combustible liquids combined should be stored outside of a flammable storage cabinet in a laboratory unless safety cans are used. When safety cans are used up to 25 gallons may be stored without using a flammable storage cabinet.
- Laboratories must limit the quantities of flammable liquids outside flammables cabinets or safety cans to the amount necessary for the work in progress.
- Storage of flammable liquids must not be immediately next to fire exit or obstruct any exit.
- Flammables cabinets are to be used for flammable chemicals only.
- Flammable liquids must be stored separately from strong oxidizers, shielded from direct sunlight, and away from heat sources.

Peroxides

Peroxides and peroxide-forming compounds, both inorganic and organic, contain a weak -O-O- bond that contributes to their reactivity and tendency for spontaneous decomposition. Their sensitivity to heat, friction, shock, or movement and can detonate, particularly when they become concentrated through evaporation, distillation, or mixing with other substances.

Labeling and Storage Requirements

- Label and store peroxide-forming reagents according to manufacturer's instructions.
- Some solvents can form explosive peroxides as they age. If crystallization is observed on or near a container, contact EHS immediately.
- Peroxides form more readily when containers have significant headspace or are exposed to air. Store these chemicals in their original containers, preferably airtight.
- Some manufacturers recommend purging the container headspace with an inert gas such as nitrogen; consult the safety data sheet (SDS) for specific guidance.

Storage Conditions

- Keep peroxide formers isolated from combustible and oxidizable materials, ideally within a flammable storage cabinet.
- Store them in a cool, dry, and dark location (out of direct sunlight).
- Only store peroxide formers in an explosion-proof or fire-proof refrigerator/freezer if the manufacturer specifically recommends it. Very low temperatures may cause peroxides to crystallize or "crash out" of solution.

Dating and Shelf Life

- Containers should be dated upon receipt and again when first opened. Write dates directly on the container.
- Peroxide formers may degrade after opening and may not remain stable until the manufacturer's expiration date. As a general guideline, they are considered safe for up to 6 months after opening and up to 1 year after receipt, regardless of use.

Testing and Disposal

- The exact peroxide concentration at which an explosion may occur is variable; however, disposal is required for materials testing at 100 ppm or higher.
- Use peroxide-testing strips to check and document concentrations regularly.
- If peroxides are detected at any level, secondary reactions may already be occurring, and disposal may be required even before reaching 100 ppm.

Procurement Considerations

- When possible, purchase stabilized grades of organic peroxide formers.
- Unstabilized peroxide formers should only be procured when technically necessary and with documented justification.
- Order quantities and container sizes that best match the intended use to minimize long-term storage and associated hazards.

Classes of Peroxides

Peroxide forming chemicals are categorized into classes (A-D), based on their likelihood of forming hazardous concentrations of peroxides and whether inhibitors are present. The tables below provide quick reference for each class; however, they may not be all inclusive.

Class A chemicals can reach explosive peroxide levels, without concentration and even prior to their container being opened. Examples include isopropyl ether and butadiene

Class B chemicals reach explosive levels of peroxides when concentrated, such as through evaporation or distillation. Examples include tetrahydrofuran and secondary alcohols.

Class C chemicals are monomers, without inhibitors, that may autopolymerize and form peroxides over time resulting in a potential explosion hazard. Examples include acrylic acid and vinyl acetate.

Class D materials are known to or suspected to form peroxides, but are not classifiable into Class A/B/C.

To see tables of more chemicals that fall into these classifications, you can visit resources such as Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards by the National Academices (nationalacademies.org/read/12654/chapter/5#72).

The following flowchart is a useful reference for how long to use and store classes of peroxide formers:

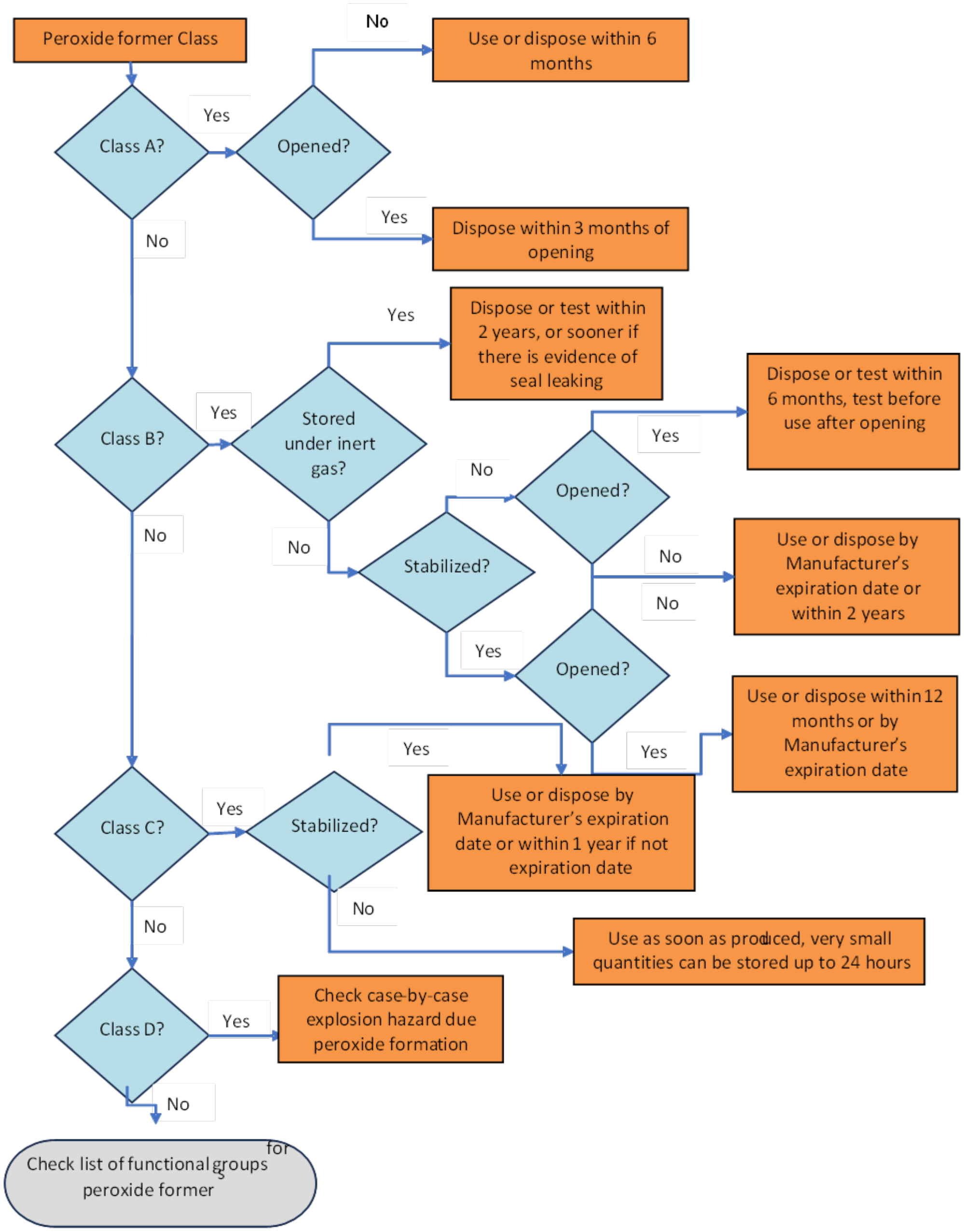


Figure 14: Time limits for storage of peroxide formers flow chart. Based on University of Southern California USC EH&S Peroxide Formers Guidance, Public Spreadsheet second Sheet.

Additional Points for Peroxide Formers

- Visually inspect containers for crystal formation or cloudiness before opening. If either of these conditions are observed, DO NOT OPEN and ALERT EHS-HAZMAT team.
- Write down directly on the container or on auxiliary label (figure 14):
  - a) Receiving date
  - b) Opening date
  - c) Lab expiration date if it is shorter than the manufacturer expiration date
  - d) Peroxide test results and date of testing
- Record peroxide test results directly on the container or on the auxiliary label.
- Verify that test strips have not expired before use.
- Any chemical that tests greater than 100 ppm should be labeled as containing peroxides, unless otherwise specified by the manufacturer.
- DO NOT return unused excess chemical back to the original bottle, or otherwise introduce trace impurities, since doing so may increase the rate of peroxide formation.

Corrosives

Figure 15: Corrosion hazard

Corrosive materials are common in research laboratories and pose significant risks to both human health and facility infrastructure due to their ability to chemically degrade or destroy living tissue and materials upon contact. These substances require careful handling, storage, and disposal to prevent injury, equipment damage, and environmental harm. Proper identification, use of personal protective equipment (PPE), and adherence to safety protocols are essential when working with corrosives. This section outlines the hazards associated with corrosive chemicals and provides guidance on minimizing exposure and ensuring safe laboratory practices.

OSHA defines a corrosive as "a chemical that causes visible destruction of, or irreversible alterations in living tissue by chemical action at the site of contact." Under the DOT hazard class system, corrosives are listed as hazard class 8. Corrosive chemicals may be acids or bases, and can be found in liquid, solid, or gaseous form.

Exposure to corrosive chemicals can cause severe damage to the eyes, skin, respiratory tract, and gastrointestinal tract. Corrosive solids and their dusts may react with moisture on the skin or within the respiratory tract, resulting in chemical burns or respiratory injury.

Handling and Use

When working with corrosive chemicals, wear PPE rated for use with the specific corrosive chemical. When working with concentrated corrosive solutions, use splash goggles instead of safety glasses. Splash goggles used with a face shield provides a higher level of protection.

Note that a face shields alone are not adequate for protection against corrosive splashes. Use of rated gloves, such as butyl rubber, and a rubber apron may also be required.

Handle corrosives in a fume hood to avoid inhaling corrosive vapors or gases.

Mixing Acids and Water

When mixing concentrated acids with water, always add acid slowly to the water. Never add water to acid, this can cause violent boiling and splattering. Pour acids gently so that it runs down the inside wall of the container. Never store corrosive chemicals above eye level, and always use a protective bottle carrier when transporting containers of corrosive chemicals.

Spill Precautions

Some chemicals can react with acids and produce toxic and/or flammable vapors. Ensure that the correct neutralizing agents are available before working with corrosives. While calcium carbonate is generally used for acids and citric acid for bases, not all corrosives are compatible with these neutralizers. Always verify the correct neutralization method by consulting the SDS for the specific chemical.

Exposure Procedures

Eyewashes and emergency showers are available near your workspace. Know their locations prior to working with corrosives.

If a corrosive chemical gets splashed in the eyes, immediately go to an eyewash station and flush your eyes for at least 15 minutes. This will seem excessive, but the length of time is important to ensure the best possible outcome. Use your fingers to hold your eyelids open and roll your eyes in the stream of water to do a full flush. After flushing for at least 15 minutes, seek medical attention immediately and complete an Injury/Illness Report as soon as reasonable afterward. Injury/illness reporting is currently available through Workday.

For small splashes of corrosives to the skin, remove any contaminated PPE and clothing, and wash the affected area with soap and water for at least 15 minutes. Seek medical attention afterward, especially if symptoms persist.

For large splashes of corrosives to the body, utilize the emergency shower and flush for at least 15 minutes. Once under the shower and the shower has been activated, remove contaminated clothing. Failure to remove contaminated clothing can result in the chemical being held against the skin and causing further chemical exposure and damage. Flush for a minimum of 15 minutes, seek medical attention and complete an Injury/Illness Report through Workday as soon as reasonable after the exposure and treatment.

Notes on Specific Acids

- Hydrochloric Acid (HCl):
    - A strong acid commonly used in laboratory and industrial applications. It is highly corrosive and can cause severe burns. Additionally, there is an important list of chemical incompatibilities. Check your manufacturer specific SDS for these chemicals.
- Sulfuric Acid (H_2SO_4):
    - A strong acid used in a variety of industrial processes, including fertilizer production and oil refining. It is highly corrosive and can cause severe burns.
- Nitric Acid (HNO_3):
    - A strong acid used in the production of fertilizers, explosives, and in metal processing. It is highly corrosive and can cause severe burns upon contact, leading to permanent damage. Inhalation of nitric acid vapors can result in serious respiratory issues, including irritation, pulmonary edema, and bronchitis. It can react violently with organic materials and other chemicals, potentially causing fires or explosions.
- Phosphoric Acid (H_3PO_4):
    - A moderate acid used in food processing, fertilizers, and detergents. It is less corrosive than other strong acids, but can still cause irritation.
- Perchloric acid ($HClO_4$):
    - A highly hazardous substance due to its strong oxidizing properties and potential to form explosive compounds. At concentrations above 85%, it can be explosive, especially when anhydrous. When heated, perchloric acid vapors can condense and form shock-sensitive perchlorate salts on surfaces, posing a significant explosion risk. It is also highly corrosive, causing severe burns to the skin, eyes, and respiratory tract upon contact[1]. Additionally, perchloric acid can intensify fires when in contact with combustible materials. Proper handling, storage, and use of specialized equipment, such as a specialized perchloric acid washdown hoods, are critically necessary to mitigate these hazards.
    - **Currently, the University does not have a specialized perchloric acid washdown hood. Therefore, heating, distillation, separation, and refining of perchloric acid *is prohibited*.**
- Picric acid (2,4,6-trinitrophenol):
    - A highly hazardous chemical due to its explosive, reactive and toxic properties. When dry, picric acid is extremely sensitive to heat, shock, and friction, making it a powerful explosive. It can also form sensitive and highly unstable salts upon contact with metals such as copper, lead, and iron. Additionally, picric acid is toxic if ingested, inhaled, or absorbed through the skin, and can cause severe irritation to the eyes, skin, and respiratory tract. Chronic exposure may result in liver and kidney damage[2]. **Use of picric acid on campus requires a**

[1] Fact Sheet: Perchloric Acid | PennEHRS
[2] Information on Picric Acid – Stanford Environmental Health & Safety

documented and valid justification demonstrating that no safer alternatives are available. Concentrations above 50 % are prohibited due the severe fire, blast, or explosion risks.

- Hydrofluoric Acid (HF):
  - A weak acid, but highly corrosive and dangerous. It is commonly used in glass etching and metal cleaning. Hydrofluoric acid is extremely hazardous due to its ability to penetrate skin and cause deep tissue damage, including destruction of bones. Unlike other acids, HF can cause severe pain and burns that may not be immediately apparent, with symptoms potentially delayed for up to 24 hours. Inhalation of HF vapors can lead to severe respiratory irritation and pulmonary edema, which can be fatal. Additionally, HF exposure can result in systemic toxicity, affecting the heart and nervous system due to the fluoride ions it releases.
  - Labs should create HF specific SOPs that highlight handling and exposure response. It is mandatory to have a HF dedicated first aid kit with calcium gluconate gel and have trained laboratory personnel in what to do in the case of HF exposures. Medical treatment should be sought, if exposed.

Always refer to the specific SDS for the chemical for potential effects and manufacturer recommendations.

Subsidiary Hazards of Corrosives:

Corrosive chemicals can also have a secondary hazard. Inhalation of vapors or mists from these substances can cause severe irritation damaging the respiratory system. Acids and bases, can be additionally classified under different hazard categories such as reactive, flammables, oxidizers, and highly toxic substances. Some can react violently with other substances and produce toxic fumes. Understanding these classifications is crucial for ensuring safe handling and use.

Figure 16: Irritant hazard pictogram

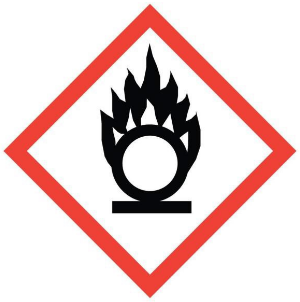
Corrosive-Flammables are capable of igniting and burning, presenting both fire and corrosion hazards. These substances can attack tissues, while also supporting or initiating combustion under the right conditions. Glacial acetic acid is an example of a corrosive chemical that is also flammable.

Corrosive-Reactives can undergo violent chemical reactions, producing heat, gas, or even explosions when mixed with incompatible materials. An example is sulfuric acid, which is highly corrosive and reacts violently with water and organic materials.

Corrosive-Toxics can be harmful or fatal if inhaled, ingested, or absorbed through the skin. An example is hydrochloric acid, which is highly corrosive and can cause severe respiratory issues if vapors are inhaled.

Corrosive-Oxidizers can also promote or accelerate combustion by providing oxygen or supporting oxidative reactions. An example is nitric acid, which is highly corrosive and can act as an oxidizing agent, enhancing the combustion of other materials.

Oxidizers



Oxidizers can cause or intensify fires and explosions by providing oxygen when heated on contact with organic compounds or other oxidizable substances. These groups of chemicals include peroxides, chlorates, perchlorates, nitrates, and permanganates. They can be solids, liquids, or gases and react strongly with organic materials and reducing agents. This reaction can lower the ignition temperature of combustible materials and expand the flammability range of gases and liquids, making fires more likely and potentially more severe. Strong oxidizing agents should be stored and used in glass or other inert containers. Cork and rubber stoppers should not be used with these substances.

To see a table of chemicals that are oxidizers, you can visit resources such as Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards by the National Academies (nationalacademies.org/read/12654/chapter/1).

Health Hazards and Toxicity

Toxic chemicals are substances capable of causing adverse biological effects when they are inhaled, ingested, injected, or absorbed through the skin or eyes. Toxicity may produce immediate (acute) effects or long-term (chronic) health consequences depending on the chemical, concentration, duration of exposure, and route of entry.

Acute health effects can include:

- **Respiratory irritation or damage**, including coughing, shortness of breath, or chemical pneumonitis
- **Eye and skin irritation**, burns, or rapid absorption leading to systemic effects
- **Central nervous system symptoms**, such as dizziness, confusion, headache, or loss of consciousness
- **Gastrointestinal distress** following ingestion, including nausea, vomiting, or abdominal pain
- **Organ irritation**, depending on chemical properties (e.g., liver or kidney stress)

Chronic health effects may develop after repeated or prolonged exposure and can include:

- **Liver and kidney damage**
- **Respiratory sensitization or reduced lung function**
- **Neurological impairment**
- **Reproductive toxicity** or developmental effects
- **Carcinogenicity**, where certain toxic chemicals increase cancer risk

Many toxic substances do not produce warning signs at low concentrations, meaning harmful exposure can occur without strong odor or immediate symptoms. Because of this, engineering controls, proper ventilation, PPE, safe handling practices, and adherence to exposure limits are essential.

The Principal Investigator (PI) and all chemical users bear responsibility for ensuring the safe use of hazardous chemicals in the laboratory. When working with toxic or extremely hazardous substances, researchers must establish a Designated Area (see glossary), which is physically separated from general lab activities and clearly labeled with appropriate warnings and/or a Chemical Hygiene Plan (CHP)/Standard Operating Procedure (SOP) specific to those chemicals.

PIs using extremely hazardous chemicals must submit the relevant Chemical Hygiene Plan to EHS for review before work begins. The CHP must clearly describe:

- The procedures, controls, and PPE required for safe handling
- Storage and segregation methods
- Decontamination and waste disposal processes
- Access restrictions for the Designated Area
- Emergency procedures specific to the hazards of the chemical(s)

This framework ensures that hazardous work is conducted safely, exposures are minimized, and compliance with regulatory and institutional requirements is maintained.

Storage

Proper chemical storage is a fundamental component of laboratory safety. Chemical quantities should be kept to the minimum necessary for ongoing research activities. Chemicals must be stored according to their hazard classes and compatibility, **not** alphabetically. Incompatible classes, such as acids, flammable liquids, halogenated solvents, oxidizers, and highly reactive materials, must be separated to prevent unwanted chemical reactions that could result in fires, toxic releases, or explosions.

Laboratories must adhere to the following guidelines:

- **All chemicals MUST be labeled.** Labels must be clear, legible, and include the full chemical name.
- **Incompatible chemicals must not be stored together.** Use compatibility charts and SDS guidance to ensure proper segregation.
- **The total amount of chemicals stored in the laboratory must be minimized.** Purchase only what is needed for short-term use or validated long-term use.
- **Chemical containers must remain closed** when not actively in use to prevent spills, vapors, and contamination.

FUME HOODS

A chemical fume hood is the primary engineering control used to protect laboratory personnel when working with hazardous chemicals. Its purpose is to remove chemical fumes, gases, vapors, and aerosols from the operator’s breathing zone by drawing contaminated air away and exhausting it safely outside the building.

Before using a fume hood, the operator must identify the types of chemicals and processes that will be conducted inside the hood to ensure it is appropriate for the task.

There are two basic categories of fume hoods:

General Purpose Fume Hoods – used for most routine chemical operations.
Special Purpose Fume Hoods – designed for specific applications (e.g., perchloric acid, radioisotopes, nanoparticle work) and equipped with specialized materials or wash-down systems.

EHS performs periodic inspection and testing of chemical fume hoods to verify performance ***and*** face velocity*.*

Researchers are responsible for utilizing their fume hoods in a manner that does not impede airflow or diminish the effectiveness of the hood. This includes keeping the sash at the appropriate height, minimizing clutter inside the hood, and ensuring that all work is conducted well within the hood's interior.

Components of a Fume Hood

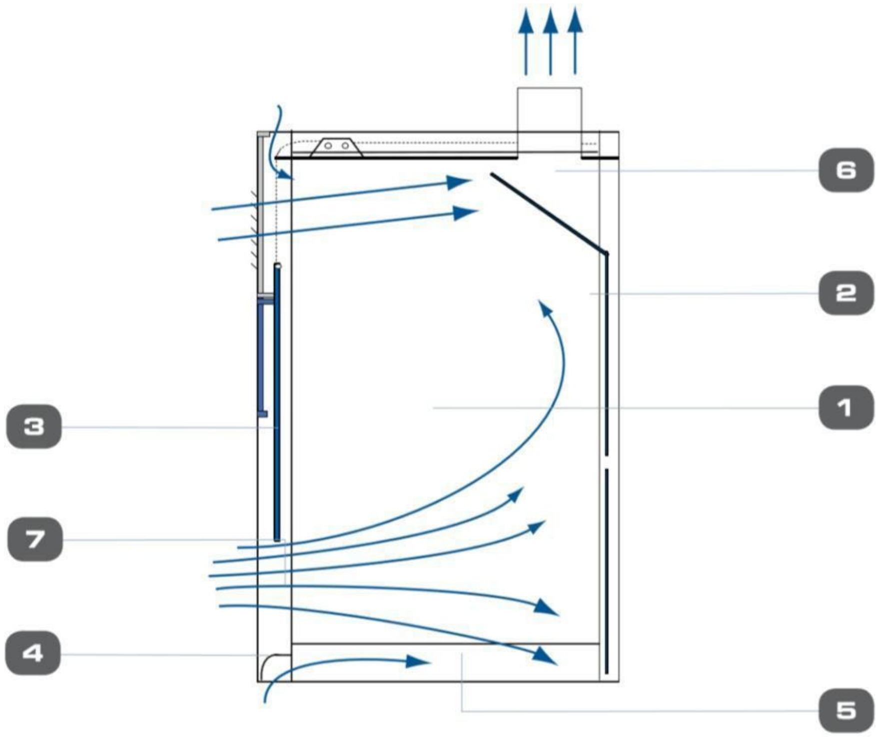


Figure 17. Laboratory fume hood schematic

1. Hood Body – The visible part of the fume hood that serves to contain hazardous gases and vapors.
2. Baffles – Moveable partitions that keep the airflow uniform to eliminate dead spots and optimize efficiency.
3. Sash – The sash is the "door" to the hood. By using the sash to adjust the front opening, airflow across the hood can be adjusted to the point where capture of contaminants is maximized. Each hood has its optimum sash configuration. The sash should be held in this position when working in the hood and closed completely when the hood is not in use.
4. Airfoil – Located along the bottom and side edges, the airfoil streamlines airflow into the hood, preventing the creation of turbulent eddies that can carry vapors out of the hood. The space below the bottom airfoil provides a source of room air for the hood to exhaust when the sash is fully closed. Removing the airfoil can cause turbulence and loss of containment.
5. Work surface – Generally a laboratory bench top, or the floor in the case of a floor-mounted hood. This is the area where the work is conducted.
6. Exhaust plenum – The exhaust plenum helps distribute airflow evenly across the hood face. Materials such as paper towels drawn into the plenum can create turbulence in this part of the hood, resulting in areas of poor airflow and uneven performance.
7. Face – The imaginary plane between the bottom of the sash and the work surface. Hood face velocity is measured across this plane.

General Safety Practices with Fume Hoods

- Work with hazardous chemicals in a properly operating, certified chemical fume hood while wearing the appropriate PPE.
- Do not use fume hoods for storage. Minimize items inside the hood and remove anything not required for the procedure in progress.
- Inspect the fume hood before each use to confirm proper function. A simple test method is to attach a small tissue streamer to the bottom of the sash and ensure it is drawn inward.
- Perform work at least six inches inside of the hood (behind the sash opening) to maintain proper containment.
- Do not obstruct baffle openings or airflow with equipment, containers, or supplies.
- Do not obstruct or manipulate baffles. Only Facilities or authorized personnel may make these adjustments.
- Do not modify laboratory ventilation systems without involvement and approval from Facilities.
- Move your arms in and out slowly and keep movements perpendicular to the opening to avoid disrupting airflow.
- Place necessary materials inside the hood before beginning work.
- Elevate large equipment, if possible, rather than placing directly on the work surface, to allow proper airflow beneath equipment.
- Never put your head inside the hood or put your face in the plane of the sash opening.
- Keep the laboratory door closed. Air currents from the door movement can disrupt hood performance.
- Locate hoods away from high-traffic areas, doors, air supply vents, or ceiling diffusers to reduce airflow disturbances.
- Avoid walking directly past an active hood when someone is working.
- Sash height should be between 7 – 15", when possible, for optimal protection. The sash should be below the face of the user.

After Using a Chemical Fume Hood

- Clear waste from inside the fume hood. Properly discard disposable supplies and store chemical waste in the designated waste storage area.
- Cap or close containers, even if they look empty. Do not allow chemicals to evaporate in the hood.
- Return chemicals to proper storage locations.
- Clean up all spills, even within the hood.
- Clean the hood after each use. Wipe down work surface and front airfoil sill. Use appropriate cleaning methods according to your SOP.

Ductless Fume Hoods

Ductless fume hoods are self-contained laboratory enclosures that filters hazardous fumes, vapors and particles through internal filtration, recirculating clean air back into the room. Because they operate on a recirculating airflow design, they do not require any external ductwork or ventilation to the outside.

The PI must verify with the fume hood manufacturer that the specific ductless hood model and its related filtration media are appropriate for the chemicals, concentrations, and procedures used in the laboratory. Ductless hoods rely on internal filters, and incorrect filter selection can result in breakthrough exposures or inadequate containment.

Laboratories are responsible for the ongoing maintenance and timely replacement of filters in ductless fume hoods, following the manufacturer's recommended schedule and performance indicators.

The PI must report the purchase of any ductless fume hood to EHS so that appropriate risk review, inventory tracking, and laboratory safety compliance measures can be maintained.

EHS does not recommend the use of ductless fume hoods due to several significant limitations:

- **Limited chemical applicability:**
  Ductless hoods can only safely handle specific chemicals, and the allowable list varies by manufacturer and filter type. PIs must follow the manufacturer's restrictions on permitted chemicals, concentrations and procedures.
- **Filter dependence and required replacement:**
  Ductless hoods rely entirely on internal filters that must be periodically replaced. Replacement intervals are specified by the manufacturer, and the PI must meet or exceed the recommended change frequency based on hood use, chemical load and breakthrough indicators.
- **User training requirements:**
  Laboratory personnel must be trained on the correct operation, limitations and capabilities of the ductless fume hood to ensure safe and effective use.

Special Purpose Fume Hoods

Certain research activities involve the use of substances which can create dangerous conditions that require specially designed fume hoods to deal with these unique conditions. The most common special purpose fume hoods are perchloric acid and radioisotope fume hoods.

Perchloric Acid Fume Hoods
See the perchloric acid section (link) for more information on these hoods.

Radioisotope Fume Hoods
For work with radio isotopes please refer to the Radiation Safety Manual.

CRYOGENS

Cryogens are defined as having a boiling point below -153°C (-243°F). The primary hazard associated with cryogens is severe cold burns from direct contact with the liquid, vapor, or cold surfaces. Common cryogenic gases used in research include argon, helium, hydrogen, nitrogen, and oxygen.

<u>*Asphyxiant hazard*</u>

Cryogenic liquids, vapors and gases can displace oxygen and create an oxygen deficient atmosphere due to their large expansion ratios when they vaporize at room temperature. Even small releases in confined or poorly ventilated spaces can rapidly create life-threatening conditions.

Requirements for use:

- Cryogenic liquids must be handled in well-ventilated areas to prevent gas accumulation.
- Gas vented or released from experiments must be adequately ventilated.
- Oxygen level detectors are required in locations where oxygen displacement is possible. Placement must reflect gas behavior:
    - Nitrogen (slightly heavier than air) many accumulate near the floor.
    - Helium (lighter than air) may accumulate near the ceiling.
- Contain EHS if there are concerns about cryogenic storage in restricted or poorly ventilated areas.

<u>*Extreme Cold*</u>

Direct contact with cryogenic liquids, vapors and gases can cause severe cold burns, frostbite or tissue damage. Do not use or store cryogens in confined or unventilated spaces. Do not place a cryogen on tile, laminated counters or flooring, as they can be damaged.

Precautions when handling cryogens:

- Maintain a safe distance from both the liquid and gas phases.
- Boiling and splashing can occur when transferring cryogenic liquids into warm containers or when inserting objects into the liquid. Perform these operations slowly to minimize the hazard of splashing.
- Gradually pre-cool receiving containers to minimize thermal shock.
- Pour cryogenic liquid slowly to avoid splattering.
- Use a discharge hose when it is unsafe or impractical to tilt large (50L or 100L) dewars.
- Wear appropriate PPE, including a face shield, cryogenic specific gloves, lab coat, long pants, and closed-toe shoes.

<u>*Explosion hazard*</u>

Cryogenic liquids can create explosion hazards if pressure builds up due to improper venting.

Requirements to prevent this hazard:

- Dewars must be kept closed with a loose-fitting cap that allows pressure to escape while preventing moisture entry.
- Ice creation on containers is normal, but if ice obstructs normal pressure-relief pathways, dangerous over-pressurization may occur.
- Only use containers specifically designed for cryogenics.

- Never store cryogens in a sealed container.

Personal Protective Equipment (PPE) for Cryogens

The following is a list of (minimum) PPE that to be used when working with cryogens:

- Face Shield
- Safety Goggles: Splash protection marked **D3** under ANSI Z87 that covers the entire eye area with no gaps.
- Lab Coat: Covering front of body and long sleeves covering entire arm and wrist.
- Cryogenic specific gloves: Cryogenic gloves are only splash resistant and are not to be used for immersion into the cryogenic liquids.
- Long pants: Legs must be completely covered, no holes or rips
- Closed toed shoes: Must be made of fluid resistant material and cover the entire foot.

Figure 18. Example of cryogenic gloves

Symptoms of Cryogen Exposure

Symptoms of cryogen exposure may appear on the skin or affect the respiratory system. Skin contact can cause rapid freezing of tissue, leading to a gray or white discoloration, a waxy or hardened feel, and blistering as the skin rewarms. Inhalation of cryogenic vapors may result in rapid or gasping breathing, reduced mental alertness, poor coordination, nausea, vomiting, and in severe cases, seizures due to oxygen displacement and asphyxiation.

Figure 19. Example showing second degree burns from cryogen contact

First Aid Procedures for Cryogenic Exposures

Skin Contact

- Remove any clothing not adhered to the skin.
- Remove jewelry from fingers if possible, especially when the hands or fingers were exposed.
- Wash the affected area with room temperature water for at least 15 minutes.
- Seek medical attention at the nearest emergency department, or call 911, for burns, frostbite, or

signs of hypothermia.

Eye Contact
- Immediately flush eyes with room temperature water for at least 15 minutes.
- Seek medical attention at the nearest emergency department, or call 911.

Inhalation
- Leave the area and move to fresh air.
- If breathing is difficult, call 911 immediately.
- Seek medical attention if any symptoms occur. Note that some symptoms may be delayed.

All incidents must be reported to your PI. Complete an injury/illness report through Workday as soon as reasonably possible.

Cryovial Use

Cryovials are commonly used for storing biological materials in liquid nitrogen. When removed from cryogenic storage, one hazard is that these vials can crack or rupture explosively. This occurs when liquid nitrogen seeps into the vial during immersion; as the vial warms, the trapped liquid rapidly expands into gas, creating internal pressure that can cause the vial to burst. To reduce this risk, internally (male) threaded cryovials are recommended.

Safe use guidelines for cryovials include:

- Use only cryovials that are certified for use in liquid nitrogen.
- Do not overfill cryovials.
- Do not overtighten the cap; allow slight venting to prevent pressure buildup.
- Wear proper PPE when handling cryovials.
- Thaw cryovials in a fume hood or biosafety cabinet.

Figure 20. Example of an internally threaded cryovial

BIOLOGICAL SAFETY

Biosafety is the collection of practices and procedures aimed at reducing the risks involved with the manipulation of biological agents to reduce or even prevent exposure. What practices and procedures are adopted for a given experiment are based on the principle of a risk assessment. While the general outline of a risk assessment has already been defined in this manual, how this applies to biosafety is through the use of **Risk Groups**, **Risk Reduction**, and **Biosafety Levels**.

Note that the Biological Safety topics covered in this manual are meant only to be a cursory overview of the principles of biosafety. For more details or a more comprehensive list of policy, please see the Biosafety Manual provided on the EHS website. Further, the policies provided herein are largely guided by the Biosafety in Microbiological and Biomedical Laboratories (BMBL), the national standard for biological lab design and best practices for safe biological research.

Risk Groups

The Risk Group (RG) of an agent is an important factor to be considered during the biosafety risk assessment process. Biological agents and toxins are assigned to a RG level based on their estimated ability to cause disease in healthy human adults and spread within the community. Briefly, there are four levels.

- Level 1 agents generally don't have the capacity to infect humans.
- Level 2 agents generally can infect humans, though are treatable.
- Level 3 agents are usually major human pathogens, though treatment and therapeutics are generally available.
- Level 4 agents are major human pathogens where treatment or therapeutics are generally not available. Level 4 agents can also be a significant community risk should they escape the laboratory.

While conducting a risk assessment, considering the RG is only the first step and the RG alone is not sufficient for determining the appropriate biosafety level for working with a specific agent.

Portals of Entry

Biological hazards generally have to enter into the body and infect to cause harm to a researcher. These portals, or routes, of entry include through the eyes, through the mouth, through the lungs, and through the skin typically via non-intact skin or absorption (e.g. toxins).

Agent Specific Considerations for Risk Assessments

Principally, the biological risk assessment will start by considering the risk factors of the agent being used:

- *Agent identity*: Identify what agents and potential hazards are present in a given sample. If you don't know, assume in principle the sample may contain an infectious agent.
- Host Range: All infectious agents have a host range. Some are limited to a particular animal host or host species while others spread to both animals and humans (zoonotic).
- *Infectious Dose:* Infectious dose levels vary by organism and should be considered, if the data is available, when selecting controls.
- *Pathogenicity*: An agent's ability to actually infect and cause disease in a susceptible host.
- *Virulence:* The severity of the disease.

- *Transmission Route*: The mechanism by which an agent is able to propagate and infect researchers.
- *Treatment:* Determine if there are effective treatments for the prevention and/or treatment of the disease.
- *Health Status*: Some agents present additional risks in immune suppressed individuals, including those who may be pregnant.

Biosafety Levels

The four primary Biosafety Levels (BSLs) for laboratories consist of combinations of the aforementioned Risk mitigation strategies, including facility design features and safety equipment, facility practices and procedures, and personal protective equipment. Selection of the appropriate combinations to safely conduct the work should be based upon a comprehensive facility-specific biosafety risk assessment that documents the properties of the biological agents and toxins to be used, potential host characteristics, potential routes of infection, and the laboratory work practices and procedures conducted or anticipated to be used in the future. It is important to note that the four Biosafety Levels described below are not to be confused and equated with agent Risk Groups, however they generally do correlate with one another but may ultimately differ depending on the specifics of the lab.

When working with well-defined organisms, identification of the appropriate biosafety controls should be based on the comprehensive biological risk assessment. However, when information is available to suggest that virulence, pathogenicity, antibiotic resistance patterns, vaccine and treatment availability, or other factors are significantly altered, an adjustment to the stringency of biosafety controls may be needed. For example, handling large volumes or high concentrations of a biological agent or toxin may require additional practices. Similarly, procedures that produce large amounts of aerosols may also require additional biosafety controls to reduce the likelihood of exposures to personnel and the unintentional release of a biological agent or toxin in the surrounding community or the environment. Furthermore, vaccines should not necessarily be considered non-pathogenic simply because they are vaccine strains.

Biosafety Level 1 (BSL-1)

BSL-1 is suitable for work involving well-characterized agents not known to consistently cause disease in immunocompetent adult humans and that present minimal potential hazard to laboratory personnel and the environment. Work is typically conducted on open benchtops using standard microbiological practices.

Biosafety Level 2 (BSL-2)

BSL-2 is suitable for work involving agents known to be potentially infectious to humans for which vaccines or therapeutics exist, generally in the RG-2 category. Equipment designed to maintain primary containment, such as a biosafety cabinet, is typically used based on risk assessment and may even be used as a means of maintaining sterility for lower risk agents. Laboratory personnel receive specific training in the procedures conducted in the laboratory and are supervised by a scientist with training in microbiology.

Biosafety Level 2+ (BSL-2+)

BSL-2+ is not a defined biosafety level in the BMBL, however it’s a level colloquially referring to laboratories designed to meet BSL-2 standards while adopting some standards required of BSL-3 or BSL-4 levels. Often this includes directional inward airflow, which is a requirement for high containment labs and traditionally comes as a recommendation for BSL-2.

Biosafety Level 3 & 4 (BSL-3 / BSL-4)

BSL-3 and BSL-4 are high containment facilities for work with major human pathogens, RG-3 and RG-4 agents. These facilities are designed heavily around engineering controls, featuring agent specific containment strategies to ensure personnel encounter minimal risk of exposure and prevent loss of containment from the facility. There are currently no BSL-3 or BSL-4 facilities at the University of Miami.

Animal Biosafety Levels 1 & 2 (ABSL-1 / ABSL-2)

The animal research laboratory can present unique concerns. Animals may generate aerosols, may bite and scratch, and/or may be infected with a zoonotic agent. While the biosafety practices, policies and procedures for work involving animal research are similar to those used in in vitro laboratory activities, the corresponding levels carry additional controls to address these added risks of working with live animals. For more specific guidance, please see the University Biosafety Manual.

Risk Reduction

The hierarchy of controls and methods to reduce risk have been discussed earlier in this manual, here we will examine how these controls are commonly applied in **biological research** settings.

Engineering Controls

The use of specialized equipment is common in a biological research environment to prevent exposures as well as maintain containment of the hazard itself. These types of equipment break down into *primary barriers* and *secondary barriers*. Equipment designed specifically to minimize occupational exposure to infectious or potentially infectious material or agents is referred to as *primary barriers*. Primary barriers include engineering controls such as biosafety cabinets (BSCs) and safety centrifuge cups. Both are designed to prevent aerosolized infectious agents from being released when handled. The design and construction of the laboratory or facility is referred to as secondary barriers. The design is intended to provide a barrier of protection for those outside of the laboratory area from exposure to an infectious agent accidently released from the laboratory.

Biosafety Cabinets

Biosafety cabinets (BSCs) are the primary containment equipment used in biological research. The major functional element of a BSC is its ability to create a near-sterile environment through the use of High Efficiency Particulate Air (HEPA) filters. Biosafety cabinets come in a variety of classes and types, and offer different types of protections based on the need of the research.

CLASS I

Class I cabinets provide personnel and environmental protection only, offering no product protection from contamination. They use un-recirculated airflow away from the operator. Class I cabinets have a similar airflow pattern to a fume hood but have a HEPA filter at the exhaust outlet. They may or may not be ducted outside. Class I cabinets are not appropriate for the use of volatile, toxic, chemicals, or radionuclides.

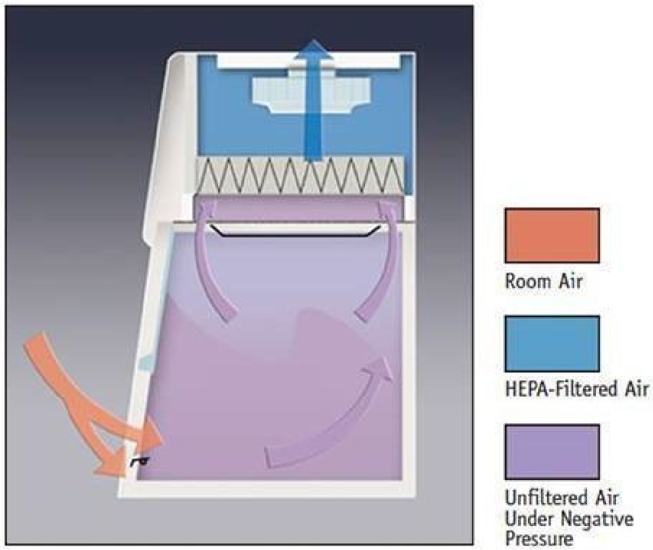


Figure 21. Biosafety cabinet airflow diagram, Class I

CLASS II

Class II cabinets provide personnel, product and environmental protection for microbiological work. Class II BSCs are designed with an open front with inward airflow (personnel protection), downward HEPA-filtered laminar airflow (product protection) and HEPA-filtered exhaust air (environmental protection). These cabinets are further differentiated by types based on construction, airflow and exhaust systems. The types include A1, A2, B1, and B2. For additional information on biosafety cabinets see the University Biosafety Manual.

- Class II Type A2 cabinets are the most common type of biosafety cabinet. They typically exhaust HEPA-filtered air back into the laboratory but may be exhausted outside using a canopy connection. Work with chemicals in Class II Type A2 cabinets is prohibited.
- Class II Type B2 cabinets exhaust all air after HEPA filtration without recirculation in the cabinet or return to the lab. For this reason, these cabinets are suitable for work involving biological agents treated with hazardous chemicals or radionuclides required as an adjunct to microbiology applications.

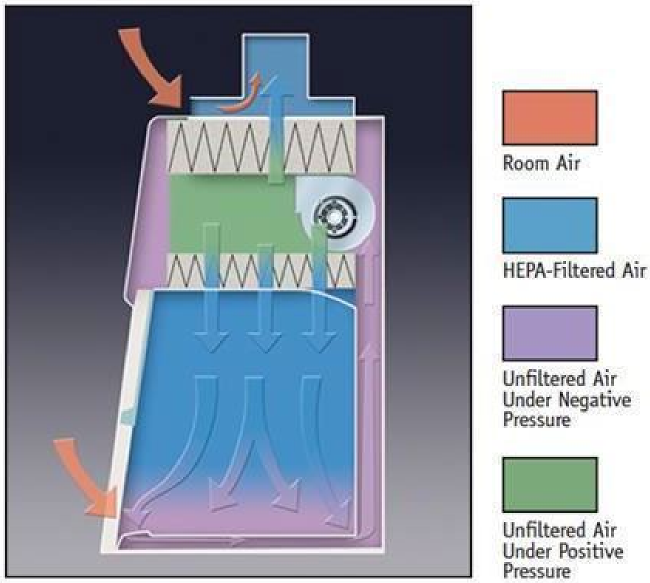


Figure 22. Biosafety cabinet airflow diagram, Class II, Type A2

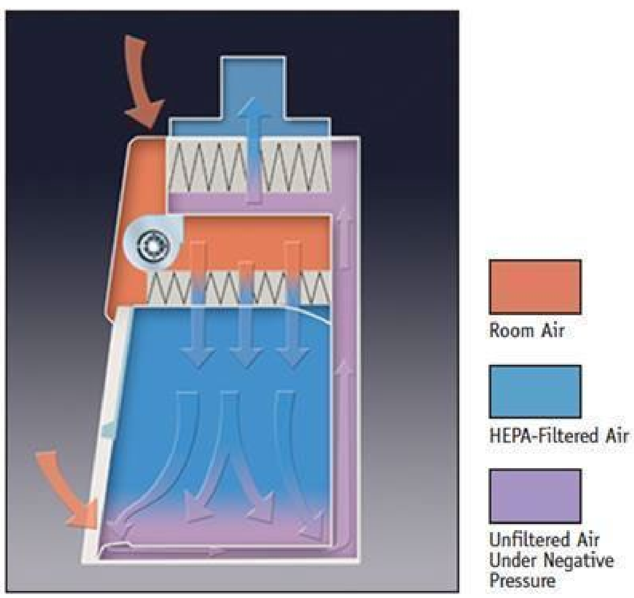


Figure 23. Biosafety cabinet airflow diagram, Class II, Type B2

CLASS III

Class III cabinets are totally enclosed with leak-tight construction and attached rubber gloves for performing operations in the cabinet. Class III biosafety cabinets are sometimes referred to as glove boxes, however not all glove boxes are Class III biosafety cabinets. The cabinet has a transfer chamber that allows for sterilizing materials before they leave the glove box. The cabinet is maintained under negative pressure and supply air is drawn in through HEPA filters. The exhaust air is treated with either double HEPA filtration or HEPA filtration and an autoclaving.

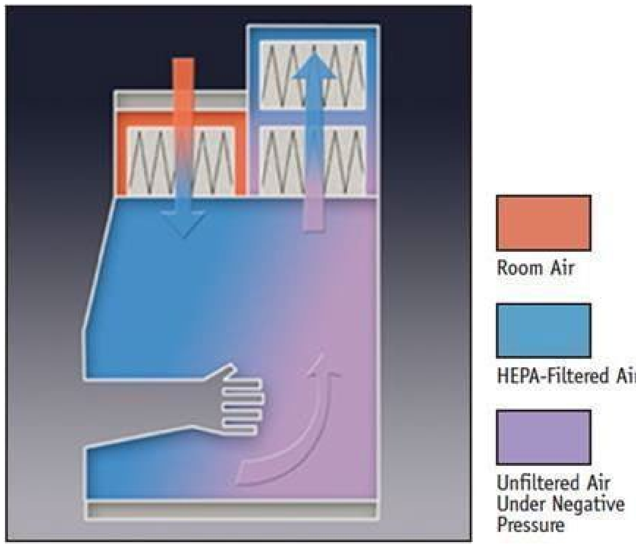


Figure 24. Biosafety cabinet airflow diagram, Class III

Additional Biosafety Cabinet Considerations

While biosafety cabinets offer essential protections and containment for conducting research, they have to be used and operated correctly in order to elicit these expectations. Biosafety cabinets must:

- Be placed away from A/C vents, doors, and other areas of high circulation or traffic.
- Be certified both annually and anytime they're physically moved from one room to another. This certification is the responsibility of the PI and can only be performed by an NSF qualified technician.
- Not be used with chemicals, unless the cabinet is a Class II Type B2.
- Be decontaminated before they're removed from a lab.
- Be used in a manner that preserves directional airflow curtains as designed. Do not block the vents. See the University Biosafety Manual for more guidance.

Laminar Flow Hoods
Not to be confused with biosafety cabinets are laminar flow hoods. The term "laminar flow" describes the air purifying action of these hoods because they provide a directed air stream through a HEPA filter. They can also be called "clean benches" because they provide a near sterile work area. However, these hoods do not provide protection to the operator from contamination and, in fact, can expose the worker to aerosols of allergenic or infectious materials. Researchers therefore must not confuse these hoods with biological safety cabinets. These hoods must not be used for microbiological work with potential pathogens.

Administrative Controls

Administrative controls are a method of risk mitigation in which a specialized safety committee or professional safety expertise can provide additional assessment of work procedures and implement safer practices. This can take the form of research proposal review, scrutinizing of SOPs, ensuring personnel in a lab are properly trained, recommending effective vaccinations and medical surveillance, laboratory inspection and assessment, and many other forms.

Biological Registration

Biological research of any nature at the University requires the completion of a Biological Registration. This registration outlines the projects performed by the lab and the materials used to complete these projects. Submissions must include a Biological Hygiene Plan to assess risk mitigation strategies by the lab. Please see the EHS Biosafety website for more guidance on how to submit a registration.

Biological Hygiene Plan

The Biological Hygiene Plan (BHP) is required for labs conducting any type of biological research. The BHP serves as a site-specific biosafety manual, in accordance with BMBL best practices, and ensures that a base risk assessment and lab specific safety SOPs are outlined for review by EHS and subsequently all lab members. For a breakdown on individual sections within the BHP, please refer to the University Biosafety Manual.

Occupational Health Program

The Occupational Health Program (OHP) is administered by the Employee Health Office (EHO) and includes a survey that must be completed individually by each member of the lab. The survey covers work exposure risks and individual health status so that a risk assessment can be conducted and corresponding health recommendations be made. *All* labs conducting biological research are subject to the OHP and personnel in these labs must complete the OHP survey to enroll.

The purpose of the Employee Health Program is to monitor the occupational health of the University of Miami community. The primary policies addressed by this program are the Bloodborne Pathogens Policy and Procedures, the Tuberculosis (TB) Infection Control Policy and Procedures and the Occupational Health Program for Animal Research Personnel Policy.

Bloodborne Pathogens Policy and Procedures (Exposure Control Plan)

The purpose of the Exposure Control Plan is to comply with OSHA's Bloodborne Pathogens Standard, 29 CFR§1910.1030. The plan is designed to eliminate or minimize occupational exposure of employees to bloodborne pathogens and other potentially infectious materials.

The Exposure Control Plan includes mandated implementation of exposure determination and risk assessment, training, notification of employees' rights, Standard Precautions (formerly known as Universal Precautions), engineering controls, personal protective equipment, and medical surveillance. For specific information regarding laboratory compliance with the Exposure Control Plan, contact EHS. The Hepatitis B Virus (HBV) is the major infectious occupational hazard in the health-care industry.

Despite the similarities in the modes of transmission, the risk of HBV infection in the health-care environment far exceeds that for other viruses of great concern, such as the Human Immunodeficiency Virus (HIV) and Hepatitis C Virus (HCV). All chemicals used to inactivate these viruses must be tuberculocidal and EPA approved.

Biological Research Committees

Specialized safety committees cover specific areas of research as dictated by regulations. Note that a single research project can be subject to review from multiple oversight committees simultaneously depending on the nature of the research. Please consult with EHS Biosafety for questions and guidance. Approval from these committees is required before any work may begin on a corresponding project. Further, materials associated with these protocols are often prohibited from being purchased until after approval has been granted, please consult with the respective committee for more guidance.

Institutional Biosafety Committee (IBC)

The Institutional Biosafety Committee (IBC) reviews all research subject to the NIH Guidelines. The NIH Guidelines covers recombinant or synthetic nucleic acid molecules. This is defined by the NIH Guidelines as (1) molecules that are constructed by joining nucleic acid molecules and that can replicate in a living cell, i.e., recombinant nucleic acids; (2) nucleic acid molecules that are chemically or by other means synthesized or amplified, including those that are chemically or otherwise modified but can base pair with naturally occurring nucleic acid molecules, i.e., synthetic nucleic acids, or (3) molecules that result from the replication of those described in / or above.

The IBC may also elect to review biological research falling outside of the scope of the NIH Guidelines, particularly if the research involves higher risk pathogens or requires special considerations and SOPs.

Institutional Animal Care and Use Committee (IACUC)

Activities that involve the use of live vertebrate animals at the University of Miami must be reviewed and approved under public laws and regulations promulgated by the Animal Welfare Act, the United States Department of Agriculture, and the Public Health Service. The Institutional Animal Care and Use Committee (IACUC) performs this function assuring that the animals will be treated humanely and in compliance with federal guidelines.

Common concerns of working in animal research environments include:

- *Allergens:* A significant portion of individuals who work with animals (10 to 40%) have or will develop allergies to animals. Symptoms which may develop include, but are not limited to, the following: urticaria, conjunctivitis, rhinitis, asthma, and anaphylaxis. Individuals with a known history of allergy are encouraged to consult with Employee Health before beginning work.
- *Zoonoses:* These are diseases that can be transmitted between animals and humans. Despite the number of animal pathogens that have the capacity to cause disease in humans, transmission of zoonotic disease in the laboratory animal environment is relatively uncommon with proper controls, including (1) the improved health status of research animals developed through comprehensive programs in veterinary care and (2) the implementation of strong occupational health and safety programs.
- *Physical Hazards*: Bites and scratches are the most common physical hazards associated with laboratory animal contact. These encounters can be minimized or eliminated through proper training and handling techniques. DVR is available to provide training to research staff in the safe handling of animals. All employees working with animals must undergo this training before beginning research. Animal handling must also include the use of a minimum level of personal protective equipment. This level may include, but is not limited to, eye protection (safety

glasses, face shield, etc.), gloves, surgical masks, respirators (see section on Personal Protective Equipment), proper clothing, and water resistant, closed-toe shoes.

- *Non-Human Primates*: Those individuals working with non-human primates require special training before working with these animals. These employees must comply with additional special precautions. This includes: (1) training on the appropriate procedures for treating animal bites and scratches, (2) training on the proper handling of primates and the appropriate use of protective clothing and equipment, (3) annual screening for M. tuberculosis (every six months), coordinated through the Employee Health Office, and (4) training addressing the potential hazards with Macacine herpesvirus 1 (Herpes B Virus). Herpes B Virus is carried by many Macaque monkeys and the infected animals are usually asymptomatic. The virus can be transmitted from monkey to people through body excretions (saliva, blood, urine, feces, etc.), needle sticks, and bites. Human infection is typically fatal. Appropriate protective clothing and eye and face protection are required and the immediate treatment of bites and scratches is critical.

The Institutional Review Board (*IRB)*

The Institutional Review Board reviews all research involving the use of live human research participants, or work that may involve materials from such participants that has not been adequately de-identified.

- *BARA Form:* All IRB protocols involving the use of the introduction of biological specimens into patients or the collection of samples from patients requires EHS Ancillary Review and the completion of the Biological Ancillary Review Assessment (BARA) form. See the University Biosafety Manual for guidance.

Intuitional Review Entity *(IRE)*

The Intuitional Review Entity reviews research in accordance with US government law requiring specific oversight for life science research that could be used for dual purposes, with the potential to serve a beneficial purpose or a nefarious purpose. This dual use research is research conducted for legitimate purposes that generates knowledge, information, technologies and/or product that can be utilized maliciously. Highly regulated biological agents/research includes:

- *DURC*: Dual Use Research of Concern (DURC) is a subset of dual use research and is defined as life sciences research that, based on current understanding, can be reasonably anticipated to provide knowledge, information, products, or technologies that could be directly misapplied to pose a significant threat with broad potential consequences to public health and safety, agricultural crops and other plants, animals, the environment, material, or national security. Research that falls under DURC is subject to IRE review. See the University Biosafety Manual for additional guidance.
- Select Agents & Toxins: Certain highly infectious and toxic agents are capable of causing substantial harm to human health and welfare. These materials are called Select Agents and are subject to federal regulation under 42CFR Part 72. The Select Agents regulation mandates that special requirements be fulfilled before a listed agent can be transferred to an institution. Research using these agents requires prior approval from the IRE and IBC. Researchers proposing the use of a

listed agent must contact EHS sufficiently in advance to allow completion and approval of all Select Agent program application requirements. The list of Select Agents can be found at the CDC website http://www.selectagents.gov/.

Work Practices

Adjusting work behaviors in the laboratory is process specific, however common biological practices include regular hand washing, techniques that minimize aerosols while pipetting, and strategically placing waste and sharps containers in relation to point of use.

Good Laboratory Practices

Listed below are examples of good laboratory practices all lab personnel working with an infectious or potentially infectious agent should follow:

- Understand the hazards associated with the agent and follow required practices and procedures related to the agent.
- Work surfaces must be decontaminated before and after all procedures. Understand your disinfectant and how it works. There is no "one size fits all" disinfectant available.
- All cultures, stocks, and other biohazardous/biomedical waste must be disposed in red biohazard bags meeting State of Florida compliance requirements and in accordance with University policy. Do not autoclave, decontaminate or treat cultures, stocks, or other biomedical or biohazardous waste prior to disposal.
- Use a secondary container to safely "transport" biological samples. Transport includes moving the samples within the lab or transporting outside of the lab.
- Clean and disinfect your biosafety cabinet before and after every procedure. Cleaning and disinfecting must include all **FIVE** interior surface areas of the biosafety cabinet: work area, rear panel, both side panels, and the sash.
- Implement a periodic disinfection schedule of equipment used to process biological samples, such as centrifuges.
- Create and maintain a readily accessible **Biohazard Spill Kit**.
- Restrict laboratory access. Only personnel working with agent should have access to the laboratory.
- Implement strict hand washing procedures. Always wash hands after removing gloves.
- No eating, drinking, smoking, applying make-up, etc. in the laboratory.
- Implement a policy for miscellaneous "lab items" such as: telephone, radio, cellular. How to use them (or not to use them) in the laboratory.
- Segregate waste properly. Do not dispose of non-contaminated material in biohazardous waste and vice versa.
- Do not crowd or clutter work area(s).

Procedures with Biological Agents

Standard microbiological laboratory practices must be implemented and followed to minimize the risk of exposure to the agent by laboratory personnel.

Examples of microbiological laboratory practices include:

- Use of mechanical pipettors in the lab.
- The safe handling of sharps in the lab.
- Procedures to minimize the creation of aerosols or splashes.
- Mechanisms that can produce aerosols in the laboratory process are: pipetting, vortexing,

sonicating, and blending.

Standard Precautions

As a result of the occupational hazards presented by HBV, HCV, HIV, and other infectious materials, Standard Precautions must be implemented. These include the treatment of all activities involving contact with blood, tissue and body fluids (including the handling of contaminated or potentially contaminated equipment or materials) as if dealing with contaminated infectious material.

The following standards of practice must be observed and conspicuously posted near first aid equipment and in all areas where the possibility of contamination by infected materials may occur:

- Hands must be washed if there is any likelihood of contact with blood, body fluids or human tissue. If soap and water are not immediately available, an antiseptic towelette shall be used as an interim measure.
- Gloves shall be worn when breaks in the skin are present or when contact with any of the following is anticipated: blood, body fluids, tissues, mucous membrane or contaminated surfaces.
- An impervious gown or apron shall be worn when splattering of clothing is likely to occur.
- If splattering, atomization or aerosolization is anticipated, appropriate protective equipment (face shield, eye protection, etc.) shall be worn at all times.
- Emergency personnel must have mouthpieces, resuscitation bags and other resuscitation devices for use in areas where the need for resuscitation is likely.
- Sharp objects shall be handled carefully.

<u>Sterilization</u>

Sterilization (wet heat) is the act or process, physical or chemical, which destroys or eliminates all forms of life including microorganisms.

<u>Disinfectants</u>

Disinfectants are physical or chemical agents that are free from infection and destroy disease or other harmful microorganisms but may not kill bacterial spores. Commonly used examples include:

- Phenolic compounds. Recommended for killings of vegetative. Bacteria, including mycobacterium tuberculosis, fungi and lipid containing virus, ineffective against spores and most non-lipid containing virus.
- Quaternary ammonium compounds. Acceptable as general use disinfectants to control vegetative. Bacteria and non-lipid containing virus. They are not active against bacterial spores.
- Aldehydes. Effective against a wide spectrum of bacteria, fungi and viruses. Sporocidal when used properly
  - Formaldehyde solutions, 8%. Exhibits good activity against bacteria spores and viruses.
  - Formaldehyde- alcohol solutions (8% and 70%) are considered very good for disinfectant purposes because of their effectiveness against bacteria spores and viruses. For many applications, this is the disinfectant of choice.
  - Activated glutaraldehydes. Good activity but toxic.
- Iodophors. Recommended for general use (70 to 150 ppm), poor activity against bacterial spores. Rapid biocidal action. Most effective in acid solution.
- Alcohols. In concentrations 70 to 95% are good as general disinfectants, no activity against bacterial spores, fast acting.

Personal Protective Equipment

The PPE required for biological research often mimics the basic pieces required for safe work with chemicals, hence the minimum PPE required for any given laboratory generally includes a lab coat, gloves, and safety glasses. Additional PPE could be as basic as the use of items geared towards preserving hygienic conditions of the lab to protect specimens from contamination, such as the use of booties and hair covers, to items of PPE that protect the wearer from inhaling major human pathogens such as a respirator.

Emergency Response

Please see the emergency response section for additional guidance.

Biohazard Spill Kit

All laboratories, including clinical research labs, working with biological agents must have a readily available biohazard spill kit. Place the biohazards spill kit near the Biological Safety Cabinet (BSC) or your workstation so that they are easily accessible in the event of a spill, so long as access to the spill kit is not restricted in the event of the spill. The supplies available in a biohazard spill kit should include at minimum:

- A copy of the spill cleanup procedures
- Nitrile disposable gloves
- Lab coat/apron
- Safety goggles
- Disposable shoe covers (booties)
- Absorbent material, such as absorbent paper towels, granular absorbent material, etc.
- All-purpose disinfectant, such as normal household bleach (diluted 1:10)
- Autoclavable bucket for diluting disinfectant
- Tongs and/or forceps, and/or dustpan and hand broom or squeegee
- Sharps waste container
- Biohazardous spill warning signage

Laboratory Waste

Nearly all labs generate waste streams that require special handling. Proper waste management is a cornerstone of laboratory safety. This section will discuss the proper management of Chemical and Hazardous Wastes, Biomedical Waste, Universal Waste, E-waste, Empty Containers, and Glass Waste.

Chemical Waste

A chemical becomes a waste when the chemical is no longer able to be used for its intended use, expired, or is abandoned or unwanted. At this point, the chemical wastes need to be prepared for disposal. All wastes, regardless of its hazards, must be properly accurately labeled with its contents and placed into the Satellite Accumulation Area (SAA). SAAs should be placed near to the point of generation of wastes and under the control of a responsible staff or faculty member. Laboratory personnel should be trained in the procedures regarding the safe and proper usage of SAAs as part of their initial lab safety training.

Hazardous Waste

Hazardous wastes are chemical wastes that are regulated at stricter standards by the EPA due to their increase risks of harm to human health. Chemicals that are listed specifically on EPA's F, K, P, or U list or have an ignitable, corrosive, toxic, or reactive characteristic are considered hazardous wastes. Hazardous wastes have additional labeling and handling requirements above those of normal chemical wastes. These wastes must also be:

- Labeled with the words "Hazardous Waste".
- Have an indication of the hazard.
- Must be closed except for adding wastes.
- Needs to be stored in the SAA in secondary containment, and segregated by hazard class.
- Containers that held P listed wastes are considered hazardous wastes, even if empty.

EHS has a fillable Hazardous Waste label template that labs can print and affix to their hazardous wastes. This label can be found on the EHS webpage under the Environmental Protection & Hazardous Materials section. Chemical and hazardous wastes are collected by the EHS hazmat team for disposal. To request a pickup of wastes, a completed Chemical Waste Disposal Form must be completed and sent to EHSChemicalWaste@med.Miami.Edu. A responsible person must be available to sign and relinquish the wastes to EHS, so it is recommended that a cell phone number be provided on the form. A copy of the Chemical Wate Disposal Form can be found on the EHS webpage under forms.

Biomedical Waste

Biomedical wastes are any solid or liquid wastes which present a threat of infection to humans, and are regulated by State and local regulations, and University policy. All generators of biomedical waste must segregate the waste at the point of generation. Biomedical was must not be mixed with other waste streams. For wastes that are both a hazardous waste and a biomedical waste, the waste shall be managed as a hazardous waste following the standards detailed in the Hazardous Waste section. Employees who handle biomedical wastes shall be trained in the proper handling of biomedical waste prior to these duties commence and annually thereafter.

Storage and Containment

Biomedical waste shall not be accumulated more that 30 days, starting at the time the first waste is added to a container. All biomedical wastes must be stored in *red* biohazard bags that meet ASTM D-1709-91 and ASTM D-1922-89 standards for puncture and tear resistance. The containers must be labeled with the generator's name and address. If a bag or container is placed into a larger container prior to transport, then the larger container is subject to the labeling requirements, and the inner container is exempt.

Sharps shall be discarded at the point of origin into a sharps container. These containers must be sealed and labeled when full. A sharps container is considered full when material in the container reaches the fill line marked on the container. If no fill line is indicated, a good rule of thumb to use is close the container when it reaches 70% full.

Disposal

Liquid biomedical wastes may be disposed of down into the sanitary sewer. Biomedical waste containers, once full and properly labeled, need to be transferred to the regulated biomedical storage area. Biomedical waste must not be stored in the lab's SAA. The procedure for disposing of biomedical waste containers differs by campus.

Medical Campus:

Biomedical waste containers must be placed in the designated biomedical waste bin located on the floor of your building. Best management practice is that the containers are sprayed down with a bleach solution prior to leaving the lab.

Gables Campus:

When a biomedical waste container is full, labs are to request a pickup of the biomedical waste by the EHS Hazmat Team by completing and submitting a Chemical Waste Disposal Form. Request waste pickups as soon as you fill a container, do not accumulate full containers in your SAA.

Marine Campus:

For labs located in the MTLSS building, a biomedical waste storage location can be found in the autoclave room on the 2nd and 3rd floor. For labs located in any of the other buildings, please request a pickup of your biomedical waste by EHS Hazmat by completing and submitting a Chemical Waste Disposal Form.

Occupational Safety

Additional hazards exist in the laboratory beyond the chemical and biological hazards outlined above.

GAS CYLINDERS

Compressed gas cylinders may present both physical and health hazards. Gases may be oxidizers, flammable, reactive, corrosive, or toxic and these properties must be considered when developing experimental procedures and designing apparatus. In addition, compressed gases, when handled incorrectly, can be very dangerous with a high potential for mechanical explosion. Although each Department of Transport (DOT) approved gas cylinder is designed, constructed, and tested to safely contain its contents, additional procedures should be followed in handling and storing compressed gas cylinders:

- Cylinders must be clearly labeled with their contents.
- Regulators must be compatible with the cylinder contents, pressure and valve.
- Cylinders (full or empty) must be properly secured at all times either by clamping to the bench or chained to the wall at all times.
- Cylinders must be stored in a cool, well-ventilated area away from sources of ignition, electricity, and heat.
- Empty or unused gas cylinders must always be capped.
- Empty gas cylinders must always be labeled as Empty and separated from full and in-use cylinders.
- Cylinder carts must be used to transport capped cylinders.
- Cylinders containing flammable gases must not be stored near oxidizers and corrosives (20 ft).
- Keep incompatible classes of gases stored separately.
- Cylinders must not be stored near corrosives liquids.
- Cylinders must be stored away from doors and exits. The Receiving Department of each campus will handle the delivery and collection of gas cylinders.
- All cylinders (new, used, or empty) must be secured at all times.
- Chains, belts, or clamps should be used to secure cylinders to the walls or benches in the laboratory.
- Do not store gas cylinders in the hallway.
- The use of disposable or lecture size cylinders is strongly discouraged.
- If special circumstances warrant the use of these types of cylinders, the Principal Investigator is responsible for the additional costs of disposal.
- Although cryogenic liquefied gases (e.g. liquid nitrogen) are generally not stored under pressure, laboratory personnel must become familiar with the special hazards associated with the use of these gases.

As gas cylinders are required to be properly restrained, the effectiveness of the restraint must be suitable for the number of cylinders used per restraint. For this reason, the number of cylinders per restraint may vary per restraint based on each individual unit. However, EHS recommends that no more than 3 to 4 gas cylinders be allowed per restraint to not compromise the efficacy of the restraint, unless the restraint used is specifically designed to and can effectively accommodate a higher number of gas cylinders.

Hazardous chemicals in gas cylinders:

- Asphyxiant chemicals: areas determined at risk by probable oxygen-deficient atmosphere shall be monitored by fixed area monitoring system or a personal atmospheric monitor (PAM)

- Highly flammables and flammables: areas determined at risk by probable explosive or blast atmospheres shall be monitored by fixed area monitoring system or a personal atmospheric monitor (PAM). Areas storing or using highly flammables or flammables shall control ignition sources and post a sign: -NO FLAMES, NO FIRE, NO IGNITIONS SOURCES- FLAMMABLE GAS
- Highly toxic or toxic: Use appropriate gas detection systems to monitor for leaks and ensure proper ventilation like gas cabinets with discharge outside the building.
- Oxidizers: areas determined at risk by probable oxygen-enriched atmosphere shall be monitored by fixed area monitoring system or personal atmospheric monitors (PAMs)

The chemical safety team will conduct a hazard assessment for asphyxiants and other hazards on a case-by-case basis, coordinating with the Facilities responsible person for the respective building. Therefore, the PI and lab staff must inform the procurement or installation of any compressed gas cylinder in their lab before it enters the University premises.

Ensure that all personnel are trained in emergency procedures and the proper use of gas cylinders and it's specific subsidiary hazards to minimize the risk of exposure and accidents.

COLD ROOMS

A cold room is considered a laboratory and is subject to the OSHA Laboratory Standard (29 CFR §1910.1450), however these spaces are not designed with appropriate airflow or to be continually occupied. A risk assessment must be conducted to determine whether the cold room is a suitable location to carry out procedures. Most cold rooms are shared by multiple Principal Investigators (PI). Therefore, all individuals using the cold room are responsible for maintaining a safe and clean area. Before entering a cold room, always test to make sure the door release mechanism is working appropriately. All items, including samples and equipment, must be properly labeled with the contents, PI's name, building and room number, and date of storage. As with any laboratory, avoid working alone in these areas.

As with all laboratories, the Lab Safety Information & Emergency Contact Card sign must be placed on the outside of the cold room, listing all PIs that use the cold room.

Common health and safety issues that can occur in a cold room when proper laboratory practices are not followed are:

- Chemical and Biological Hazards
- Mold Growth
- Structural Damage

Chemical and Biological Hazards inside Cold Rooms

The storage of chemicals in the cold room must comply with the OSHA Laboratory Standard (29 CFR §1910.1450) and University policies and procedures. Most cold room's air circulation is not exhausted. Therefore, careful attention needs to be made with the storage of chemical and biological hazards and work with these materials in these spaces is prohibited. Most cold rooms are not designed as explosion proof spaces.

Certain chemicals are not permitted to be used in cold rooms. These include:

- Highly toxic or toxic chemicals
- Highly flammable or flammables
- Corrosive to metals chemicals, if construction materials of cold room are made of metals
- Asphyxiant chemicals, **including dry ice**
- Time sensitive chemicals and peroxide formers that have stabilizers that are affected by the low temperature
- Chemicals defined as incompatible or reactive with low temperatures (section 7 of SDS)

Mold Growth

Mold requires moisture, nutrients, and a substrate to grow. Mold can grow in a cold room due to condensation and improper housekeeping. To reduce the amount of condensation that forms inside a cold room, and thus prevent mold growth on surfaces, follow the recommendations below:

1) *Minimize personnel activity inside the cold room. Entrants into the cold room should know exactly what they are going to be doing, and what they need prior to entering the space. Have a plan before going through the door.*
2) *Avoid the use of any storage items made from porous materials (e.g. cellulose containing materials, wood, cardboard, paper products, and absorbent materials) as these materials support microbial growth. Instead, store these items directly on the metal shelf or in glass/plastic containers with lids that provide a good seal.*
3) *Keep surfaces clean. Wipe surfaces of countertops, work benches, table surfaces and shelves. If space is shared, establish a regular cleaning schedule and describe responsibility of each group.*
4) *Upon entering the cold room, perform a visual inspection, check for mechanical and structural issues (e.g. condensation, broken evaporator units and fans, faulty latches and door seals, inconsistent temperatures). If you identify any issues contact Facilities Work Control for the appropriate campus:*
    a. *Gables Campus: 305-284-8282*
    b. *Medical Campus: 305-243-6375*
    c. *Marine Campus: 305-421-4815*
5) *Mold is not likely to amplify when the relative humidity is below 65%.*
6) *Minimize the amount of outside air entering the cold room by keeping the door closed, reducing entry frequency or installing a plastic curtain if possible.*
7) *Remind your colleagues to follow these suggestions or put signs outside the cold room so they don't forget.*

To report mold concerns, please contact the EHS Industrial Hygiene team at 305-243-3400.

For more information on mold in cold rooms, please see the following NIH document.
https://ors.od.nih.gov/sr/dohs/Documents/cold-room-mold.pdf

Structural Damage

Excess moisture or spilled chemicals can cause structural damage such as rust and corrosion. This damage can compromise the integrity of the shelving, equipment, and structure of the cold room.

Periodically review the inventory of your items in the cold room and remove any items not in use, expired, or have mold.

After every use:

- Replace any missing or illegible labels.
- Clean up any spills.

- Close the cold room door firmly.
- Report any leaks or malfunction to Facilities.

Occupational Exposure Assessments

EHS offers exposure monitoring of hazardous substances in the air or on surfaces of the workplace. We can monitor the exposure levels of an employee throughout a procedure or a work shift to ensure they are within health and safety guidelines limits. This can be done for particulates, chemicals (gases like formaldehyde, organic vapors, Isoflurane) or to monitor physical hazards (noise levels).

Please call EHS Industrial Hygiene team to set up an assessment.

Fire Safety

Ensuring fire safety in a laboratory is paramount in protecting personnel, experiments, and equipment. Guidelines and regulations on fire safety in the laboratory are derived from the National Fire Protection Association **(NFPA) 45 Standard Fire Protection for Laboratories Using Chemicals**. NFPA 45 applies to all laboratory buildings, units, and work areas in which hazardous chemicals are handled or stored.

Although each laboratory setting can be unique, NFPA 45 provides six basic requirements for the protection of life and property as well as the control of fires and explosions involving the use of chemicals in laboratory-scale operations:

1. **Chemical Storage and Handling**: The safe storage of flammable and combustible materials away from ignition sources.
2. **Ventilation Systems**: Adequate ventilation to prevent the buildup of hazardous vapors.
3. **Electrical Safety**: Proper grounding of equipment and safe wiring practices.
4. **Fire Prevention**: Minimize open flames, use non-sparking tools, and maintain clear pathways for egress.
5. **Training and Education**: Laboratory personnel should receive proper training on fire safety, chemical handling, and emergency response. It is the responsibility of the Principal Investigator (PI) to ensure lab personnel have received the appropriate training for the lab.
6. **Emergency Procedures**: Laboratories must have well-defined emergency procedures, these should include evacuation plans, fire alarms and fire extinguisher locations. Refer to your UReady Continuity Plan for additional information.

Emergency Egress and Evacuation

The PI shall be familiar with emergency procedures for the laboratory and regularly review these procedures with employees. Laboratory personnel must keep traffic areas free of obstacles and obstructions. Chemicals are to be properly segregated and stored on level, stable shelves or in approved storage cabinets, never on floors, window ledges or balconies. Exits from laboratories are to be kept clear and unobstructed to provide full instant use in the event of fire or other emergency. The hallways outside each laboratory are not be used for storage or office space. These areas must be kept free and clear to provide emergency egress during an evacuation.

If the fire alarm is activated, it is to be treated as a fire event, and everyone is to evacuate using the nearest accessible exit and assemble at the designated meeting site. Handicapped individuals are to be escorted into the exit stairwell landing if located above the ground floor. Advise fire rescue personnel of their location upon their arrival to the building.

In case of fire, remember **RACE**:

R **Rescue** persons in immediate danger
A **Alert** others by activating the building fire alarm and calling 911
C **Confine** the fire by closing doors
E **Extinguish*/Evacuate** to the designated meeting site

*Any attempt to extinguish the fire must only be done after the building fire alarm and 911 response have been activated, the fire is small and contained, the appropriate extinguisher is available, and the user has been trained on how to use a fire extinguisher. If the fire cannot be extinguished after using one fire extinguisher, close all doors and evacuate the building. Assemble at the designated meeting site.

Safe evacuation is the primary goal during a fire.

STOP, DROP and ROLL

If you or your clothes catch fire, stop, drop and roll. Stop, drop to the ground, and cover your face with your hands. Roll over and over or back and forth until the fire is out.

If you cannot stop, drop, and roll, use a fire blanket if available, to help you or others smother the flames. Cover the person with the blanket to smother the fire.

Proper laboratory safety training, adherence to standard operating procedures (SOPs), and good housekeeping are essential for maintaining a safe laboratory environment.

Fire Safety Devices

There are a variety of safety devices designed to deal with fire emergencies. These devices can be categorized into two basic types: fixed and portable.

Fixed Devices
These include fire alarms, pull stations, standpipes, fire hoses, smoke detectors, and automatic sprinkler systems. They are designed to provide automated detection (smoke detectors) and emergency containment (automatic sprinkler systems) for the laboratory as well as to assist trained emergency response personnel (standpipes and fire hoses) in dealing with fires. Pull stations should be activated by laboratory personnel only in the case of a fire emergency.

Figure 25. Examples of a pull station, a smoke detector and a sprinkler head

<u>*Portable Devices*</u>

The primary portable fire safety device is the fire extinguisher and shall comply with **NFPA 10 Standard Installation of Portable Fire Extinguishers**. These devices are designed to extinguish only incipient fires. Every laboratory must have a fire extinguisher within at least 50 feet unless otherwise specified and conspicuously located – readily accessible and available in the event of a fire. The fire extinguisher must be of the capacity and class appropriate to the volume and type of chemicals and equipment used in the specific laboratory. Fire extinguishers must also be inspected annually by qualified personnel, and visually checked by maintenance personnel monthly.

Fire extinguishers are classified as follows:

A		Ordinary Combustibles	Wood, Paper, Cloth, Etc.
B		Flammable Liquids	Grease, Oil, Paint, Solvents
C		Live Electrical Equipment	Electrical Panel, Motor, Wiring, Etc.
D		Combustible Metal	Magnesium, Aluminum, Etc.
K		Commercial Cooking Equipment	Cooking Oils, Animal Fats, Vegetable Oils

To use a fire extinguisher, remember **PASS**:

P Pull the pin
A Aim at the base of the fire
S Squeeze the handle
S Sweep from side to side

Never throw water on electrical fires (Class C) or flammable liquid fires (Class B).

All fire extinguishers in laboratories are rated for Class A, B and C fires. For those laboratories using combustible metals, Class D fire extinguishers will be provided or contact EHS to have them installed.

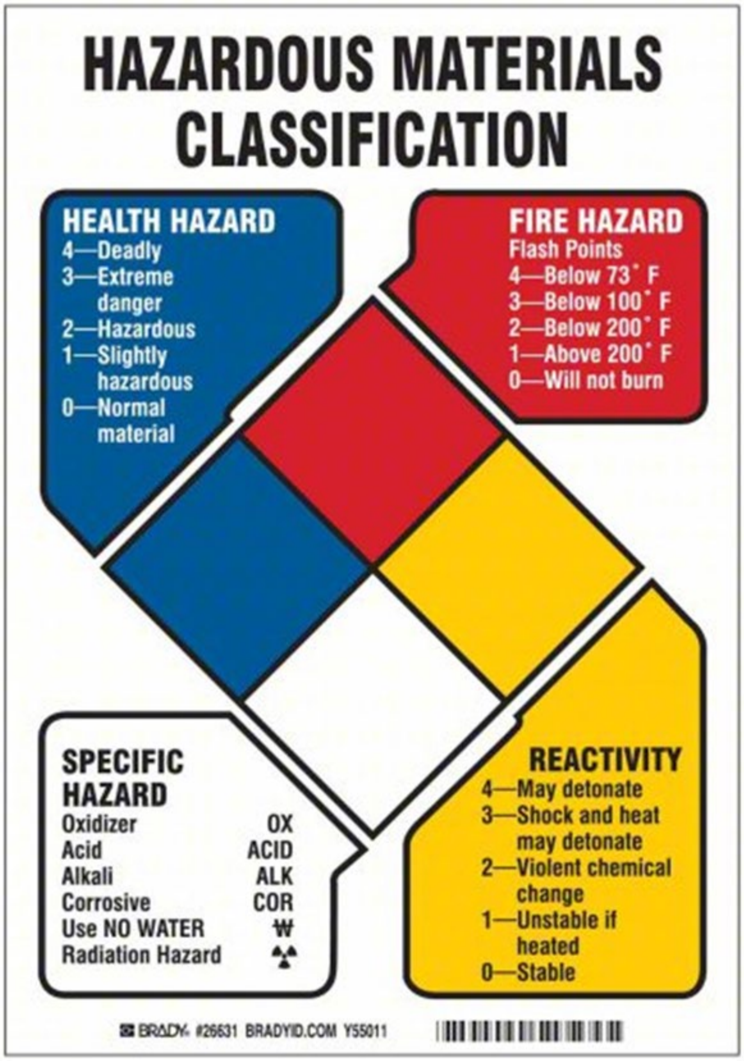
Once a fire extinguisher has been used, it must be removed from service to be recharged – contact Facilities Work Control for assistance.

For additional information on the development of evacuation plans and practical training on how to use fire extinguishers, contact the EHS Fire Safety team.

NFPA 704 Diamond

Commonly known as the “fire diamond”, the NFPA 704 hazard label is a system created to quickly show the dangers of chemicals used in laboratories and other places. The label has four color-coded sections arranged in a diamond shape:

- **Blue (Health Hazard)**: Shows how dangerous the material is to health, from 0 (no hazard) to 4 (very dangerous).
- **Red (Flammability Hazard)**: Indicates how easily the material can catch fire, from 0 (won’t burn) to 4 (very flammable).
- **Yellow (Reactivity Hazard)**: Tells how likely the material is to react chemically, from 0 (stable) to 4 (may explode).
- **White (Special Information)**: Gives extra hazard details, such as whether the material is an oxidizer, reacts with water, or needs special handling.



Laboratories can use NFPA 704 labels effectively by following these best practices:

- **Proper Placement**: Put NFPA 704 labels on all chemical containers, storage areas, and lab entrances. This helps emergency responders quickly identify any hazards.
- **Regular Updates**: Keep the labels current with the latest hazard information. Update them when new chemicals are added or existing ones are re-evaluated.
- **Employee Training**: Teach all laboratory staff how to read and understand the NFPA 704 labels. Knowing what each color and number means is key to safety.
- **Consistent Labeling**: Use the NFPA 704 system the same way throughout the laboratory. This makes it easy for everyone, including new employees and emergency responders, to understand the hazards.
- **Compliance with Regulations**: Check with local authorities to ensure compliance with any specific requirements for using NFPA 704 labels.
- **Routine Inspections**: Regularly check that all labels are legible and in the right place. Replace any that are damaged or faded.

Ceiling clearances and storage

1. Storage shall be maintained **2 ft**. or more from the ceiling in non-sprinkled areas of buildings.
2. The clearance between the deflector and the top of storage shall be **18 inches** or more in sprinkled

areas of buildings throughout the horizontal plane. (Source: NFPA 1 (FL) Fire Code, Chapter 10).

Electrical Safety

It is important for all laboratory personnel to understand their electrical needs and not overload the electrical systems in the building. Contact Facilities Work Control for an assessment or modification to the laboratory's electrical needs or requirements.

Electrical Cords

All electrical equipment should be checked regularly for wear and tear. Any equipment with damaged cords or plugs must be removed from service and reported for repairs or replacement. Electrical cords must not be affixed to structures; extend through walls, ceilings, or floors, or under doors or floor coverings; or be subject to environmental or physical damage.

Extension Cords

Extension cords over time tend to develop cracks that can lead to electrical shocks. Do not use electrical tape to cover these cracks, instead purchase new ones and properly dispose of these damaged extension cords. The best solution is to place your electrical devices within reach of the electrical outlets. If extension cords must be used, they must be UL listed and are permitted for a period **not exceeding 90 days**.

The ampacity of the extension cords shall not be less than the rated capacity of the portable appliance supplied by the cord and shall be maintained in good condition without splices, deterioration, or damage. The extension cords are not to be "daisy-chained"; or affixed to structures; extend through walls, ceilings, or floors, or under doors or floor coverings; or be subject to environmental or physical damage. Extension cords shall not be used as a substitute for permanent wiring. (Source: NFPA 1 (FL) Fire Code, Chapter 11).

Furnaces and Ovens

A laboratory furnace or oven is a high-temperature heating device specifically designed for use in scientific and industrial laboratories. It provides controlled, uniform heat for various applications such as material testing, chemical reactions, and sample preparation. When using furnaces or ovens, the following are required:

1. **Pre-Operation Checks**:
    a. **Inspect Equipment**: Ensure all furnaces and ovens are in good working condition. Check for any signs of damage or wear.
    b. **Clear Surroundings**: Keep the area around the equipment free of flammable materials and clutter.
    c. **Ventilation**: Verify that the ventilation systems are functioning properly to prevent the buildup of hazardous fumes.
2. **During Operation**:
    a. **Monitor Temperatures**: Always monitor the temperature settings and ensure they do not exceed the recommended limits.
    b. **Use Appropriate Containers**: Only use containers and materials that are rated for the

temperatures being used.

c. **Use only dedicated chemical fume hoods**: Muffle furnaces may be placed inside dedicated chemical fume hoods, provided no chemicals or other combustible materials are also inside the fume hood:

d. **Stay Alert**: Never leave the equipment unattended while in operation. Assign a responsible person to monitor the process.

3. **Post-Operation**:

e. **Cool Down**: Allow the equipment to cool down completely before performing any maintenance or cleaning.

f. **Inspect and Clean**: Regularly inspect and clean the equipment to prevent the buildup of combustible materials.

g. **Report Issues**: Immediately report any malfunctions or safety concerns to the appropriate personnel.

Ground Fault Circuit Interrupters (GFCI)

Ground Fault Circuit Interrupters (GFCIs) are quick-response circuit breakers that cut off electrical power to avert electrocution risks within an electrical system. Typically installed in areas prone to moisture, like near sinks, in bathrooms, and around showers, they are essential safety devices. It is important to note however, that critical equipment, including freezers and refrigerators that need an Uninterruptible Power Supply (UPS), should not be connected to GFCI outlets to ensure uninterrupted operation.

Loose Fitting Plugs

Plugs for all electrical equipment should fit securely in their sockets. Loose fitting plugs can cause the equipment to overheat and catch fire. Regular physical checks to ensure that the plugs have not loosened is highly recommended.

Overloading Circuits

If too many devices are plugged into a circuit, the current will heat the wires to a very high temperature, which may cause a fire. If the insulation around the wires melts, arcing may occur and cause a fire.

Space Heaters

Space heaters are permitted for research purposes to maintain optimal temperatures for sensitive experiments. When using space heaters, the following conditions must be observed:

1. **Use approved space heaters:** Only use space heaters that are approved for laboratory use by EHS. Contact the EHS Fire Safety team for approval.
2. **Placement**: Place heaters on a flat, stable surface away from flammable materials and high-traffic areas.
3. **Supervision**: Never leave space heaters unattended while they are on. When not in use, space heaters should be securely stored.
4. **Electrical Safety**: Ensure the heater is plugged directly into a wall outlet, not an extension cord or power strip, to prevent overheating.
5. **Regular inspections**: Regularly inspect the heater for any signs of damage or wear and ensure it is functioning properly. If any damage is detected, remove the space heater from service and either repair or replace it.
6. **Clearance**: Maintain a safe distance around the heater, at least three feet, to prevent accidental contact or obstruction.
7. **Automatic Shutoff**: Use heaters with an automatic shutoff feature in case they tip over or overheat.
8. **Training**: Ensure all laboratory personnel are trained on the proper use and safety procedures for space heaters.

By following these precautions, laboratory personnel can safely use space heaters to maintain the necessary conditions for their experiments.

Surge Protectors

The use of UL listed surge protectors is allowed for all electrical equipment in laboratories that do not require an Uninterrupted Power Supply (UPS). For equipment that requires UPS, these must be plugged directly into the red outlets. The University's recommended surge protector is Tripp-Lite: industrial/medical grade.

Water spills on Electrical Equipment

No electrical equipment should be operated or switched on if it has been in contact with water. Water increases the risk of electrocution especially if the equipment's insulation is damaged. Switch off the main power connection, unplug the wet or damp equipment and dry it out completely. Contact our Facilities Work Control and/or manufacturer to have an electrician check the equipment to confirm that it is safe to use.

Micromobility Devices with Batteries

Micromobility devices are devices that have a battery, such as e-scooters, e-bikes, e-skateboards, and hoverboards, are a range of small, lightweight electric or motorized devices used for transporting an individual at speeds that do not exceed 25 km/h (16 mph), excluding motorized wheelchairs, bicycles, mopeds and motorcycles.

Due to the associated fire risk from charging lithium-ion batteries which power most of these micromobility devices, they are not allowed to be stored or charged inside any University owned or operated facility including laboratories and associated offices, means of egress and exit stairwells.

These devices are to be secured outside at designated racks and not in any pedestrian walkways or breezeways.

Laser Safety

The laser safety program at the University of Miami ensures safe and compliant use of lasers in research, following federal and state regulations. While OSHA lacks a specific laser standard, it references ANSI Z136.1, Safe Use of Lasers, as the primary guide for laser safety.

The Florida Department of Health Bureau of Radiation Control regulates lasers under Chapter 64E-4.001, F.A.C., requiring registration of all Class 3B and 4 lasers and notification of any incidents or near-misses.

The program includes, but is not limited to:

- Implementation of control measures to eliminate or reduce laser hazards
- Routine inspection of laser and laser systems
- Investigations of incidents involving lasers,including accidents and near-misses
- Designation of a Laser Safety Officer (LSO)
- Education and training for laser users and observers

Laser Classifications

Lasers are divided into safety classes ranging from Class 1 to Class 4. This classification system is determined by the potential of the laser beam to harm skin or eyes during normal use.

Class 1

A laser or laser system that is incapable of emitting hazardous radiation under normal operating conditions.
Note: Certain Class 1 lasers may contain embedded higher-class lasers, which remain subject to applicable control measures.

Class 1M

Any laser or laser system incapable of emitting harmful radiation under normal circumstances and may still pose a risk of ocular injury if observed through collecting optics, such as a microscope.

Class 2

A laser or laser system that emits radiation capable of causing eye injury with prolonged exposure. Class 2 lasers operate at wavelengths in the visible spectrum (approximately 400-700 nm). The normal blink reflex, occurring within 0.25 seconds, generally offers protection from beams produced by Class 2 lasers.

Class 2M

Any Class 2 laser or system capable of causing eye damage when viewed through collecting optics like binoculars or microscopes.

Class 3R

A continuous wave (CW) laser generates moderate levels of either visible or invisible radiation. Class 3R lasers have an output power ranging from 1 to 5 times the Class 1 power limit for wavelengths below 400 nm (UV lasers) or above 700 nm (IR lasers), or an output power of 5 mW for wavelengths between 400 nm and 700 nm (visible lasers). The likelihood of injury or fire is considered low, except in cases of prolonged exposure to eyes or extended skin contact.

Class 3B

Any laser or laser system that is able to produce damaging radiation causing injury to the eye upon direct viewing and reflection. Class 3B continuous wave (CW) lasers have a power output of 5 – 500mW. Class 3B pulsed lasers have a power output of <0.03Joules (J) and a pulse width of <0.25 seconds (human blink reflex). Class 3B lasers and laser systems must be registered with EHS.

Class 4

Any laser or laser system that is able to produce damaging radiation causing fire and injury to the eye and skin upon direct viewing and reflection. Class 4 continuous wave (CW) lasers have a power output of >500W. Class 4 pulsed lasers have a power >0.03 Joules (J). Class 4 lasers can be operated in all wavelengths. Class 4 lasers and laser systems must be registered with EHS.

Acquisition of New Lasers

Before bringing a laser to the University of Miami, the Laser Safety Officer (LSO) needs to be notified with the details of the laser, the area the laser will be used, and the purpose of the laser. This includes lasers used for demonstrations, entertainment purposes, and lasers on loan.

The following needs to be completed before use of the laser will be approved.

- The laser must be registered at EHS using the Laser Registration Form. More information can be found on the EHS website under Laser Safety.
- Any fabricated laser made or used for use at the University must be registered with the LSO regardless of Class.
- Complete Basic Laser Safety training either in-person with the LSO, or on ULearn or Blackboard Ultra.
- Submit an SOP (Standard Operating Procedure) which included the laser procedures, emergency procedures, location of eyewear and a list of laser users. The SOP must be posted on the wall of the laser room or kept nearby where easily accessible.
- Barriers (or curtains) must meet ANSI and NFPA standards to prevent the laser beam from leaving the designated area, thereby preventing injuries and equipment damage.
- Appropriate laser safety eyewear must be purchased and easily accessible to anyone who will be entering the area *prior* to entrance.
- Appropriate laser warning sign(s) posted on the entrance to the laser area.
- Appropriate warning signals, such as lights or illuminated signs installed to notified persons when a laser is in use.
- For Class 3B and 4 lasers practical Fire Extinguisher training must be completed with the EHS Fire Safety Manager.
- A Clean Guard fire extinguisher must be installed in close proximity to any Class 3B and 4 laser. Contact Facilities Work Control for installation.

EHS registers the Class 3B and 4 lasers with the State of Florida on behalf of Principal Investigators. Control measures must not be tampered with at any time. Labels posted on the laser by the manufacturer must not be removed. An inspection by the LSO or an EHS representative will occur twice a year.

Laser Pointer Safety

Laser pointers are safe when used correctly as a visual aid. If used incorrectly they can cause eye injury. When choosing a laser pointer choose low powered laser pointers (Class 2 or below). Red and orange lasers with wavelengths of 633 – 650nm are the safest. Never point a laser pointer at a person, animal, or reflective object. Never point a laser pointer at a vehicle or aircraft. This is federal law as the light can temporarily blind pilots.

Emergencies

All laser injuries and near misses must be reported to the Laser Safety Officer (LSO) at 305-243-3400 within 24 hours of occurring. Injuries must be reported through Workday as soon as reasonably possible.

Eye Related Accidents:

Medical Campus: For accidents involving the eyes, go to the Bascom Palmer Eye Institute emergency department.

Location: 2nd floor, 900 NW 17th St, Miami, FL 33136
Phone: 305-326-6170

Coral Gables and Marine Campuses: Go to your nearest emergency department if able or call 911.

Skin Related Accidents:

If you experience any injury or suspected injury related to the laser, immediately seek medical attention. Go to the nearest emergency department for examination.

Laser Disposal

The LSO must be notified if a laser is no longer in use or there is a need for disposal/removal. Class 3 and 4 lasers must never be disposed of in regular trash. If you no longer need your laser, options may include:

1. Contacting the laser manufacturer to see if they will take it for spare parts or disposal.
2. Donating it to another institution.
3. Donating it to another lab within the University of Miami.
4.

Medical Use Lasers

For information on medical use lasers contact the Division of Occupational Health, Safety and Compliance at UHealth.

Radiation Safety

Radiation safety at the University of Miami is governed by the **Radiation Control Center (RCC)**, which maintains the University's **Non-Human-Use Radiation Safety Manual**. This manual outlines the rules and regulations adopted to ensure both safety and compliance with state and federal requirements. Copies of the manual can be obtained by contacting the RCC directly (see contact information below).

The use of radioactive materials and ionizing radiation-producing devices at the University is regulated by the **State of Florida** under an agreement with the **U.S. Nuclear Regulatory Commission (NRC)**. The RCC is the designated authority responsible for overseeing these activities.

Individuals intending to use radiation within University of Miami facilities must contact the RCC prior to initiating any work. This ensures proper training and authorization are in place. It is important to note that **all radioactive materials**, including those classified as **Generally Licensed**, are regulated. No quantity is exempt from oversight.

All radioactive material disposal must comply with **State of Florida regulations** and be conducted under protocols approved by the **University of Miami Radiation Safety Committee**.

Radiation Control Center
305-243-6360
1600 NW 10th Avenue, Suite 1081A RMSB
Miami, Florida 33136
http://facilities.med.miami.edu/divisions/radiation-cont

Emergency Response

Exposures

In the event of an exposure to hazardous material, immediately address the exposure with an appropriate response based on the circumstances. Injuries must be reported using the injury/illness report process in Workday, as well as to Employee Health at (305) 243-ONEU or (305) 243-6638 and follow the automatic prompts.

Eye Exposures
Hold eyelids open and wash both eyes at the nearest eyewash station for 15 minutes.

Full Body Exposure
Move to the nearest emergency shower and turn on. Remove contaminated clothing and wash entire body for 15 minutes.

Needlesticks / Hand or Arm Exposure
Wash area of exposure with soap and water while scrubbing at the site of exposure for 15 minutes.

Reporting
All exposures must be reported as soon as reasonably possible.

Chemical Spills

Chemical spills can occur at any time and place where chemicals are used. Each laboratory must maintain a Chemical Spill Kit appropriate for the types and quantities of chemicals in that laboratory. This kit must be labeled and accessible. The following are the recommended components of a basic chemical spill kit:

- Polypropylene or high-density polyethylene bucket with top (appropriate size for a potential spill volume)
    - Should be well labelled and easily accessible to all members of the laboratory. The purpose of this item is to act as a receptacle for chemical resistant bag liners during a spill clean-up and as a storage container for the spill kit components.
- Personal protective equipment
    - Safety eyewear: Spare safety glasses and/or goggles should be included in the spill kit.
    - Gloves: Spare gloves compatible with the types of chemicals the skill kit is designed to contain.
    - Aprons / Shoe covers / Lab coats / other PPE: Refer to the SDS to ensure that all of the requirements for PPE have been fulfilled.
- Tools
    - Small brush and dustpan
    - Scoops
- Inert absorbents such as vermiculite, sand, clay, absorbent socks or pillows, etc...
- Neutralizing and treatment materials – (type and quantity are dependent on the laboratory's chemicals)
    - Acids Spills: Sodium bicarbonate, sodium carbonate, and commercial kits designed for acid spills are sufficient for neutralizing many acids. Some of the commercial kits have color indicators to show when a spill has been neutralized.
    - Alkali Spills: Citric acid, sodium bisulfate, and commercial kits designed for

alkali or caustic spills are sufficient for neutralizing many bases. Some of the commercial kits have color indicators to show when a spill has been neutralized.

- Solvent Spills: Commercial solvent treatment materials may be used to reduce vaporization and raise the flash points of some solvents.
- Chemical resistant bags
- All spill residue and spill clean-up material needs to be placed in a high density polyethylene or polypropylene bag.

It is the responsibility of laboratory personnel to clean small chemical spills in their labs as soon as they are identified, if it is safe to do so. Notify the EHS hazmat team if assistance is needed to clean the spill and to schedule removal of the spill response material.

In the event that a spill exceeds the capacity of your spill kit, or is highly hazardous, laboratory personnel must evacuate, secure the area, and notify the EHS hazmat team. Do not hesitate to call 911 if there is a need for medical assistance or a significant threat to life or health. It is recommended that lab personnel stay nearby in a safe area to provide details to emergency responders regarding the spill, such as such as specific location of the event, chemical hazards, other potential hazards, estimated chemical/hazard quantities, etc...

Biological Spills

Biological spills are treated differently from chemical spills as the immediate primary hazard is the risk of aerosol formation from the impact of a biological spill and the risk of inhalation of biohazards for those in the vicinity of the spill. Before lab personnel clean a spill, a risk assessment of the agent should be performed to determine whether additional assistance from EHS is needed before proceeding. Further, the steps for cleaning a biological spill vary depending on whether the spill is in the open laboratory or in a biosafety cabinet.

Biological spills at the University of Miami are classified as either major or minor. A major spill is a spill event that cannot be handled safely without the assistance of EHS emergency response. A minor spill is a spill event that can be handled safely without the assistance of EHS emergency response. During a biological spill, the primary concern for local research staff is potential for inhalation of an aerosol. Thus, spills occurring inside of a biosafety cabinet (BSC) are easier to manage as the BSC will contain any generated aerosols created by the spill. Therefore, spills are addressed by researchers based on whether they are major or minor, and whether they take place inside the biosafety cabinet our outside of the biosafety cabinet.

Major Spills Inside the Biosafety Cabinet

1. Keep the BSC on.
2. Close the sash of the BSC.
3. Attend to injured or contaminated persons.
4. Alert personnel in the area of the spill and post a sign on the BSC sash that indicates the nature and the time of the spill.
5. Call EHS (305-243-3400).
6. EHS to arrange clean-up.

Major Spills Outside the Biosafety Cabinet

1. Avoid inhaling airborne materials while quickly leaving the room. Notify others to leave the room and close the door.
2. Post a sign on the door indicating the nature and time of the spill.
3. Remove contaminated clothing/PPE.

4. Wash all exposed skin with soap and warm water.
5. Call EHS (305-243-3400).
6. EHS to arrange clean-up.

Minor Spills Inside the Biosafety Cabinet

1. Keep the BSC on.
2. Change PPE.
3. Cover spill area with absorbent material.
4. Pour liquid disinfectant onto the absorbent material from the outside of the spill area, moving in.
5. Allow for appropriate contact time.
6. Collect spill material and dispose of as biohazard waste.
7. Spray/wipe walls, work surfaces, and equipment with disinfectant solution and allow for appropriate contact time before wiping up residue.
8. Decontaminate grill pans if applicable.
9. Dispose of all spill clean-up materials as biohazard waste.
10. Allow for the BSC to run for at least 10 minutes after cleanup and before resuming work.
11. Notify users that spill cleanup is complete.

Minor Spills Outside the Biosafety Cabinet

1. Avoid inhaling airborne materials while quickly leaving the room. Notify others to leave the room and close the door.
2. Post a sign on the door indicating the nature and time of the spill.
3. Remove contaminated clothing/PPE.
4. Wash all exposed skin with soap and warm water.
5. Wait 30 minutes to allow aerosols to settle before entering the spill area for cleaning.
6. Don appropriate PPE.
7. Cover spill areas with absorbent material.
8. Pour liquid disinfectant onto the absorbent material from the outside of the spill area, moving towards the center. Allow for appropriate contact time.
9. Collect absorbent material and dispose of as biohazard waste.
10. Spray work surfaces, cabinets and equipment surrounding the spill area with appropriate disinfectant solution and allow for appropriate contact time before wiping up the areas with absorbent materials.
11. Remove PPE and wash hands.
12. Notify users that spill cleanup is complete.

Contact Information

General – All Campuses

Emergency	911
Environmental Health & Safety	ehs.miami.edu/ 305.243.3400
Main Office	305-243-3400
Biological Safety	305-243-3269
Chemical Safety	305-243-8443
Hazardous Materials	305-243-3268
Fire Safety	305-243-8443
Industrial Hygiene	305-243-8443
Office of the Vice Provost for Research & Scholarship IRB, IBC, IACUC DVR	provost.miami.edu/leadership-areas/vice-provosts/research-and-scholarship 305.284.3356 305.243.2311 305.243.2310
Safety Data Sheet Access	https://chemmanagement.ehs.com Hotline at 888.362.7416
Employee Health	Office: 305.243.3267 **24 Hotline: 305.243.6638**
Radiation Control Center	305.243.6369 305.243.6360
Telecommunication for the Deaf (TTD)	305.284.3512
Faculty & Staff Assistance Program (FSAP)	305.284.6604
Sexual Assault Response Team (SART)	305.798.6666
Cane Watch	877.415.4357
Workplace Equity and Inclusion	305.284.3064
Poison Information Center	800.222.1222
University Switchboard	305.274.2211
Office of Research Compliance	305.284.4636
Risk Management	305.284.3163
Office of General Counsel	305.284.2700
Whistleblower Protections	877-415-4357
Florida Suspicious Activity Hotline	855.352.7233

Coral Gables Campus

Campus Emergency – UM Police Department	305.284.6666
Facilities Customer Service	305.284.8282
Human Resources	305.284.3798
Counseling Center	305.284.5511
Student Health Center	305.284.9100
Dean of Students Office	305.284.5353
Information Technology	305.284.6565

Marine Campus (Rosenstiel School of Marine, Atmospheric and Earth Science)

Campus Emergency	911
Campus Safety – Primary	305.710.7991
Campus Safety – Alternate	305.421.4766
Facilities Customer Service	305.421.4815
Human Resources	305.421.4325

Medical Campus (Miller School of Medicine & UHealth)

Campus Emergency – Security Department	305.243.6000
Non-Emergency – Security Department	305.243.7233
Facilities Customer Service	305.243.6375
Human Resources	305.243.6482
Information Technology	305.243.5999

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Guidelines for Laboratory Design: Health, Safety and Environmental Considerations, 4th Edition; Louis J. DiBerardinis, Janet S. Baum, Melvin W. First, Gari T. Gatwood, Anand K. Seth; John Wiley & Sons, 2013

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National Research Council (US) Committee on Prudent Practices in the Laboratory. *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards: Updated Version*. Washington (DC): National Academies Press (US); 2011. Available from: https://www.ncbi.nlm.nih.gov/sites/books/NBK55878/ doi: 10.17226/12654

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