WAKE FOREST UNIVERSITY

Chemical Hygiene Plan

2023 Revision

Table of Contents

1. INTRODUCTION

The Chemical Hygiene Plan (CHP) reviews policies, procedures and responsibilities that protect faculty, staff and students from the physical and health hazards associated with chemical exposure within the lab.

The CHP is required under OSHA's Occupational Exposure to Hazardous Chemicals in Laboratories standard (29 CFR 1910.1450), referred to as the "Lab Standard".

National Research Council's (NRC) 2011 edition of Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, referred to as "Prudent Practices," is available in each lab's electronic Laboratory Safety Notebook (see Section 4.1.1). "Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by recognized authorities in the laboratory community through the sponsorship of the NRC.

2. COMPONENTS OF A CHEMICAL HYGIENE PLAN

The elements of the Chemical Hygiene Plan may be found at 29 CFR 1910.1450(e)(3). Summarized briefly, these eight elements are as follows:

1. Standard Operating Procedures when using hazardous chemicals
2. Control measures to reduce exposure (engineering or administrative controls, PPE)
3. Proper fume hood performance and maintenance
4. Information and training for employees on the CHP
5. Prior approval requirements for certain lab activities
6. Medical consultation and examinations
7. Responsibilities within the CHP
8. Working with Particularly Hazardous Substances.

The following sections will cover the eight elements in a generalized form. Not all information will be pertinent to each laboratory.

The Principle Investigator (PI) may need to provide additional information for specific hazards within the individual lab. Contact your PI or EHS if you have questions or need to make adaptations to the plan.

3. RESPONSIBILITIES UNDER THE CHEMICAL HYGIENE PLAN

3.1 University Administration

a. Ultimate responsibility within the University, and along with the University President, the Provost and other administrators, provides continuing support for the CHP.

3.2 Department Chair

a. Ensure compliance with the Lab Standard within the department.
b. Working with the Provost, Office of Research and Facilities and Campus Services, ensure appropriate resources are allocated to provide proper and adequate administrative and engineering controls to protect faculty, staff and students from the health hazards associated with the hazardous chemicals within the department.
c. Notify the University Chemical Hygiene Officer when any new hazards are introduced into the department.
d. Ensure Principal Investigators have completed required training.
e. Notify Environmental Health and Safety upon hiring or employment termination of Principal Investigators within the department.

3.3 Principal Investigators (PI)

a. Ensure compliance with the Lab Standard within their respective laboratories.
b. Develop, review and update Standard Operating Procedures (SOP's) for laboratory specific hazards, as required.
c. Ensure all personnel working within the lab have completed required training.
d. Notify the Department Chair and EHS when any new hazards are introduced into the laboratory.
e. Provide adequate Personal Protective Equipment for all personnel working within the lab.
f. Maintain and update laboratory roster.
g. Maintain chemical inventory within the lab and be aware of the location of Particularly Hazardous Substances within the lab.
h. Report all accidents, injuries, and illnesses to the Department Chair and EHS.

3.4 Laboratory Personnel

a. Apply good chemical hygiene practices as outlined in the CHP.
b. Participate in required training.
c. Always use the appropriate personal protective equipment provided.
d. Assist PI in ensuring compliance with the Lab Standard within the lab.
e. Read and be familiar with lab specific SOPs and the Laboratory Hygiene Plan.
f. Report all accidents, injuries, and illnesses to the PI.

3.5 Environmental Health and Safety (EHS)

a. Ensure overall University compliance with the Lab Standard.
b. Assign University Chemical Hygiene Officer as liaison to departments.
c. Review general and lab specific SOP's.
d. Provide training, as required, to laboratory personnel and Principal Investigators.
e. Conduct laboratory inspections on a regular basis for all appropriate environmental, health and safety requirements for compliance with federal, state and local regulations.

f. Collect and dispose of waste chemicals generated within labs.
g. Provide appropriate signs for identification of laboratory hazards.
h. Provide chemical spill clean-up.

3.6 University Chemical Hygiene Officer

a. Maintain and update the University Chemical Hygiene Plan, as required.
b. Review general and lab specific SOP's.
c. Point of contact for PI's regarding compliance with federal, state and local regulations and assistance with laboratory chemical and occupational health related issues.
d. Investigate accidents, injuries, and illnesses and any potential environmental, health or safety hazards identified by laboratory personnel.
e. Maintain University chemical inventory system.

The current Chemical Hygiene Officer is Steve Fisenne, Director of EHS. He can be reached at x3427 or fisennsw@wfu.edu.

4. CONTROL MEASURES

Control measures are in place to prevent exposure to harmful chemicals. These can include administrative or engineering controls.

4.1 Administrative Controls

Administrative controls are also known as work practice controls. These are changes in work procedures such as written SOPs, general safety rules, or training that will result in reducing or eliminating the duration, frequency and severity of exposure to hazardous materials or hazardous situations.

4.1.1 Laboratory Safety Notebook

Each Faculty member will be assigned an online **Laboratory Safety Notebook** on the WFU Google Drive. This electronic notebook is the central repository for documentation required in the lab (aside from SDS), as well as a point of reference on laboratory safety. The notebook is to be shared with all laboratory researchers, staff researchers, and graduate and undergraduate researchers working in the lab.

The Laboratory Safety Notebook folder includes the following subfolders:

1. *Laboratory Specific Safety Training*
2. *Laboratory Protocols*
3. *Laboratory Equipment*
4. *Chemical Inventory / Safety Data Sheets / Microorganism Risk Groups*
5. *Waste Management*
6. *Laboratory Incident Report Forms*
7. *Emergency Response Contacts*

The Laboratory Safety Notebook is intended to serve as the main source of information on lab safety for lab personnel.

4.1.2 Standard Operating Procedures

Standard Operating Procedures (SOPs) are written instructions that provide detailed information on performing a laboratory process or working with a chemical effectively and safely.

SOPs can be specific or generic depending on the application. These may range from "working with inorganic acids" to "working with hydrofluoric acid", for example. Wake Forest University has developed a number of SOPs for common laboratory work. These are located in Appendix I. In addition, a template SOP has been developed to allow individual laboratories to develop their own SOPs for laboratory specific situations.

It is the PI's responsibility to provide written SOPs specific to potential safety and health risks arising from use of hazardous chemicals or procedures within the lab. These SOPs should include, but are not limited to, work with:

- *Particularly Hazardous Chemicals*, as defined by OSHA, and includes carcinogens, reproductive toxins, and substances with a high acute toxicity.

- *Highly Reactive Chemicals*, including highly reactive or unstable chemicals that may polymerize or decompose violently, are shock sensitive, or may react violently when exposed to pressure, temperature, light, water, or another material . Examples are pyrophorics, explosives, azides, and organic peroxides.
- *Select Agents and Toxins*, as defined by the Center for Disease Control (CDC).

4.1.3 General Safety Rules

Prudent Practices (pgs. 15-17) describes a number of General Safety Rules for working in the lab. Below are listed ten basic safety procedures that must always be followed:

1. Do not work alone when using hazardous materials. If an incident occurs, help will not be available.
2. Always follow Standard Operating Procedures, and never perform unauthorized experiments.
3. Read the Safety Data Sheet (SDS) and label prior to using a chemical.
4. Always wear appropriate PPE. Eye protection and closed toed shoes are mandatory for anyone entering a laboratory. At no time may sandals or other open toed shoes be worn in the lab.
5. Use a fume hood whenever working with hazardous chemicals.
6. Know the location of, and how to use, emergency equipment (i.e. safety shower, eyewash, fire-extinguisher).
7. Make sure other lab workers are aware of any special hazards associated with your work, and be aware of hazards posed by the work of others within the lab.
8. Never ingest anything in the lab. No eating, drinking, chewing gum, etc. This is only to be done in approved break areas.
9. Immediately report any injuries, accidents or near-misses to the PI.
10. Report any unsafe conditions to the PI.
11. Properly dispose of all chemical waste, following directions found in this CHP.

4.1.4 Housekeeping

Good housekeeping must be practiced when working in the lab. Referring to Prudent Practices (pgs. 113-114), the following are some essentials to good housekeeping:

1. Don't block exits and leave aisles open. Keep clearance around emergency equipment (eyewashes, fire-extinguishers) and make sure electrical panels are not blocked.
2. Close drawers and cabinets when not in use. This especially applies to the doors on fire cabinets.
3. Properly label all chemical containers. This includes transfer vessels, which must be labeled with the chemical name and hazard class. Store all chemicals with the label outward for easy identification.
4. Do not store incompatible material together.
5. Never store glass bottles on the floor, where they may be inadvertently knocked over.
6. Close all chemical containers unless you are adding or removing contents.
7. Secure cylinders to walls or benchtops with chains or straps.
8. Keep all containers at least 2 inches from the edge of benchtops to avoid knocking them onto the floor.
9. Clean up spills, even minor spills, immediately. This applies to liquids and solids.
10. Don't pile up dirty glassware in the sink. "Clean as you go". Piles of dirty glassware can hide potentially dangerous broken glass and sharp edges. Place a rubber mat at the bottom of the sink to prevent glassware from breaking.
11. Dispose of broken glass in clearly labeled and lined Broken Glass boxes.

12. Sharps and needles are not to be reused, and must be placed in an authorized Sharps Disposal container.

4.1.5 Chemical Substitution

One very useful Administrative Control is the policy of substituting a hazardous chemical with a less hazardous chemical whenever possible when working within the laboratory. One example currently in practice is the elimination of mercury thermometers with alcohol thermometers whenever possible. This practice eliminates potential mercury exposure in the event of a thermometer break, as well as the time and expense of cleaning a mercury spill.

4.1.6 Chemical Inventory

All locations on campus where chemicals are used and stored must be inventoried. An accurate inventory is important as both a regulatory and sustainability measure.

4.1.6.1 Chemical Inventory System

Chemical inventory will be maintained in the University designated program, ChemWatch. The system is available to all lab members. All chemicals received are to be bar-coded in the system prior to use or storage. Empty chemical bottles are to be scanned out of the system. It is the responsibility of the PI to ensure the laboratory chemical inventory is accurate and up-to-date.

4.1.6.2 City of Winston-Salem Fire Marshal

The Winston-Salem Fire Marshal's Office conducts annual inspections of all campus buildings to ensure compliance with the NC Fire Prevention Code. The Fire Prevention Code regulates the maximum quantity of flammable liquids that may be stored, per floor, per building. Accurate chemical inventory is essential to ensure compliance with this regulation.

4.2 ENGINEERING CONTROLS

Engineering controls provide a physical barrier between the hazardous chemical and the individual working in the lab. These include ventilation, fume hoods, bio-safety cabinets and personal protection equipment. A fume hood vents chemical fumes and vapors out of a work area to the outside of the building. A biological safety cabinet circulates air so a laminar flow forms that prevents cultures or other materials inside the work area from being contaminated by the outside air. Laminar flow of air also prevents aerosols or microbes inside the hood from escaping.

4.2.1 Ventilation

Standard building or room ventilation does not suffice as protection from airborne hazards. The use of fume hoods or bio-safety cabinets in addition to ventilation is necessary to provide adequate protection.

The purpose of room ventilation is two-fold:

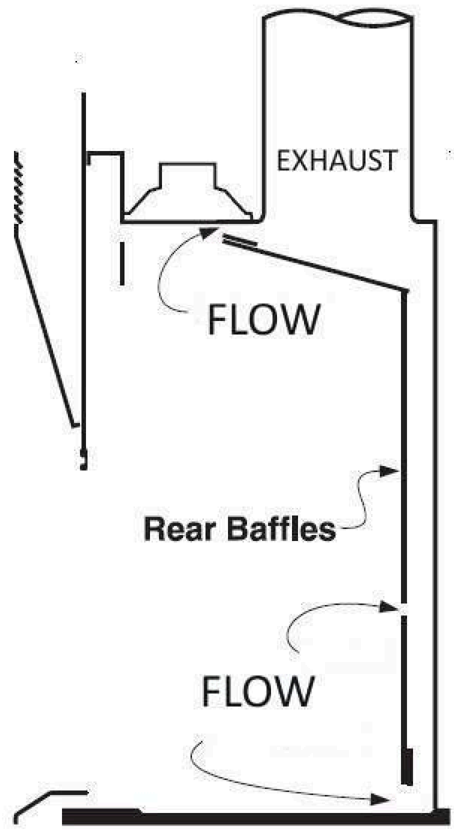
1. Provide adequate heating and cooling to make a comfortable working environment, and
2. Provide a pressure differential between the lab and non-lab adjacent spaces to prevent uncontrolled chemical emissions from leaving the lab.

4.2.2 Fume Hoods

As stated in Prudent Practices, page 221, "Laboratory chemical (fume) hoods are the most important components used to protect laboratory personnel from exposure to hazardous chemicals and agents."

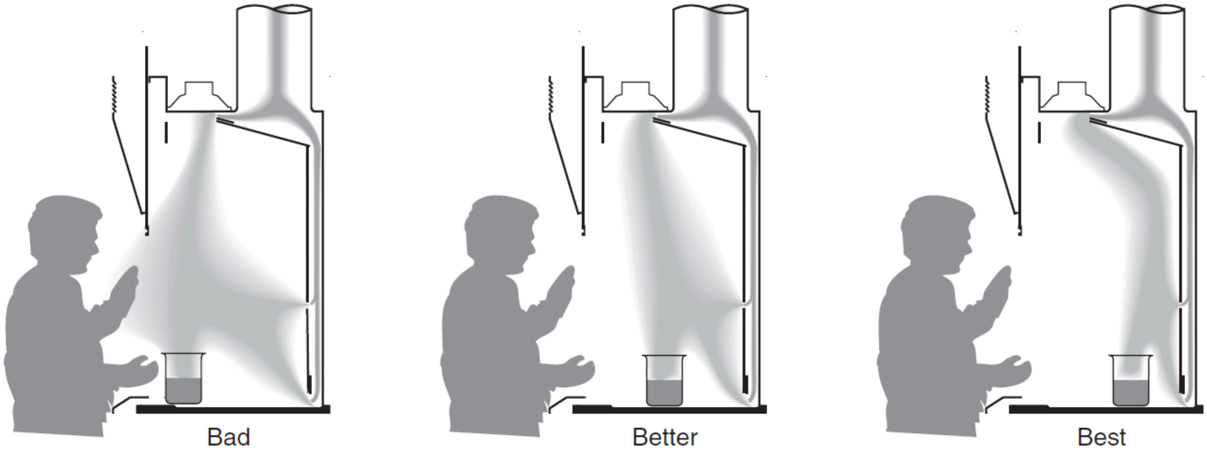
4.2.2.1 Fume Hood Design and Function

The fume hood is designed to protect the lab worker by providing an enclosed barrier between the worker and airborne dust, powders and vapors within the hood. The directional flow will carry the harmful contaminants toward the baffles at the rear of the hood and into the exhaust, where large volumes of air dilute the contaminant prior to discharge through the stack on the building roof.

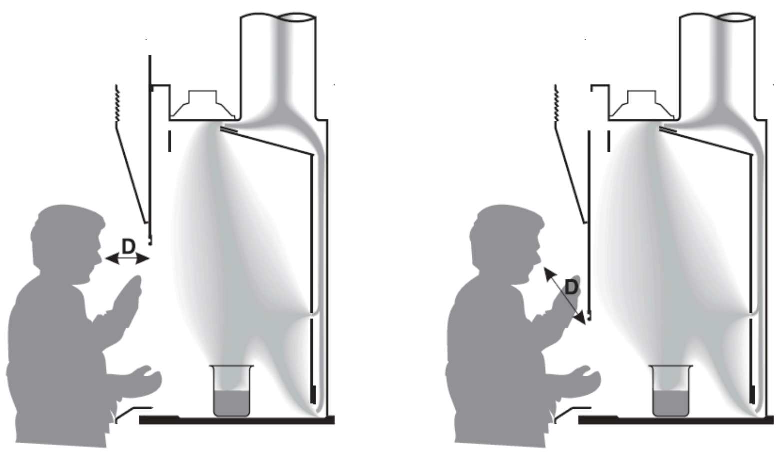


Side view of typical chemical fume hood showing air flow.

Placement of the source of hazardous material will influence potential exposure. It is noted in Prudent Practices, page 223, "chemical (fume) hood containment tests reveal that the concentration of contaminant in the breathing zone can be 300 times higher from a source at the front of the face than from a source placed at least 6 in. back." See diagrams below (Kewaunee Scientific Corporation, *Operating and Maintenance Procedures, page 5*.)



Lowering of the sash will also help eliminate exposure by increasing the distance between the breathing zone and the area where contaminants may escape from the hood (see D, below). Additionally, lowering the sash also limits the external effects of room disturbances on flow. (Kewaunee Scientific Corporation, *Operating and Maintenance Procedures, page 7*.)



Be aware that room air flow disturbances include foot traffic. Prudent Practices, page 222, indicates the vortices formed behind an individual walking can exceed 250 fpm. This is enough to overcome the draw into the hood, thus pulling contaminant fumes from the hood into the laboratory. Foot traffic near fume hoods should be limited when the hood is being used.

4.2.2.2 Fume Hood Air Flow

The face velocity of a fume hood is an average air velocity across the front, or face, of the hood at the sash. The velocity is measured in feet per minute (fpm). Recommendations by several organizations suggest face velocity should be maintained between 60 and 120 fpm.

4.2.2.3 Fume Hood Use

Prior to using a fume hood:

1. Know how the hood works.
2. Know the hazards of the chemicals to be used. Consult the SDS.

3. Ensure hood is on.
4. Make sure sash is open to the proper operating level, as indicated by the marks on the frame.
5. Make sure the air flow gauge is reading between 60 and 120 feet per minute.

When using the fume hood:

1. Keep your head out of the hood at all times.
2. Use proper eye protection, gloves, and lab coats.
3. Be sure nothing is blocking the airflow through the airfoil at the front of the hood and the baffles in the rear of the hood.
4. Elevate equipment at least two inches off the base of the hood.
5. Keep all materials at least six inches from the sash opening.
6. Do not open and close the sash rapidly, as this will cause turbulence and disturb flow.
7. Close the sash when work is complete.

Fume Hood Housekeeping:

1. Keep the hood and adjacent areas free of clutter.
2. Keep airfoil and baffles clear to allow proper air flow.
3. Minimize the amount of equipment in the hood to prevent blockage of airflow.
4. Do not permanently store any chemicals in the hood.
5. Remove any unnecessary items from the hood.
6. Do not use the hood as a means of intentionally disposing of compressed gases or to let solvents evaporate.

4.2.2.4 Fume Hood Maintenance

Facilities and Campus Services (F&CS) maintain all fume hoods on campus. If a fume hood alarm sounds, it is indicating that the air flow is not within intended range. Closing the sash will often recalibrate the flow and silence the alarm. However, if the alarm continues, it is no longer safe to use the hood. Close the sash fully and place a note on the sash stating:

DANGER. DO NOT USE. HOOD OUT OF ORDER.

Next, call F&CS Customer Service at x4255 and place an Emergency Work Order to have the hood repaired. Do not use the hood until F&CS has responded to the Work Order, and has made appropriate repairs.

4.2.3 Constant Volume Hoods

Several fume hoods in campus laboratories are “constant volume hoods”, meaning there is no associated control valve to modulate air flow. Constant volume hoods will continue to pull air at the same rate with the sash open or closed. However, since the fan rate is not equivalent to the velocity, the feet per minute of air flow will decrease as the sash is opened. (Air is being drawn through a larger surface area, reducing velocity). Be aware that the higher the sash is open, the lower the fpm will be and will increase the chance of fugitive emissions. Constant volume hoods are typically operated by a switch. Make sure the switch is on and the fan is running prior to using this type of hood.

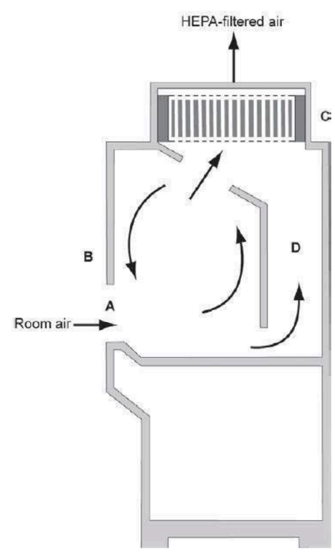
4.2.4 Biosafety Cabinets

Biosafety cabinets (BSC) are located in laboratories that typically work with biological organisms. The BSC is designed to protect both the worker and the material within the cabinet. They are the main means by which protection is offered to lab personnel from potentially infectious microorganisms. There are three types of BSCs, designated Class I, II and III. The information and all figures for this section are from Center for Disease Control and Prevention (CDC) publication, *Biosafety in Microbiological and Biomedical Laboratories, 6th Edition (BMBL).* This publication should be read by all lab personnel prior to working with a BSC.

4.2.4.1 Class I

Class I BSC will provide protection to lab personnel and the environment, but will not protect the material (organism) within the cabinet. Air is drawn inward across the opening at the front of the BSC and then filtered, usually through a High Efficiency Particulate Air (HEPA) filter. Often, the BSC I will be used to enclose equipment, such as centrifuges or fermenters, where the possibility of aerosolization of product may occur.

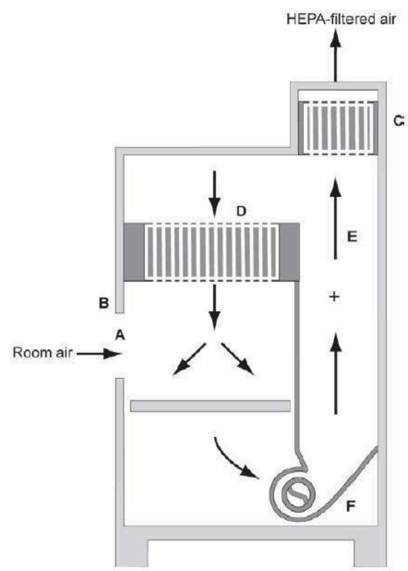
The Class I BSC (A) front opening; (B) sash; (C) exhaust HEPA filter; (D) exhaust plenum. *Note:* The cabinet needs to be hard connected to the building exhaust system if toxic vapors are to be used.



4.2.4.2 Class II

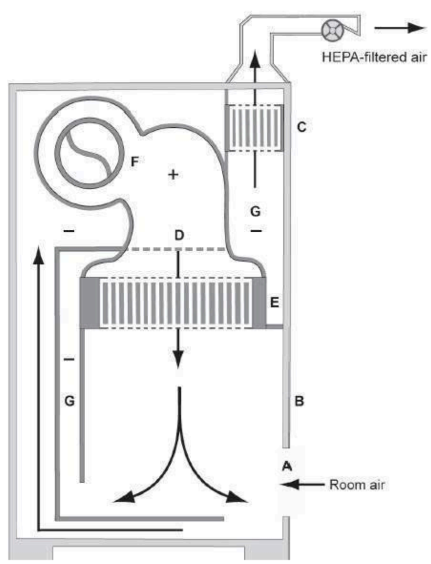
Class II BSCs provide protection for lab personnel, the environment and the material within the cabinet. Class II BSCs are further divided in four types: A1, A2, B1 and B2. Airflow enters through the front grille of the cabinet, where it is HEPA filtered prior to passing into the cabinet work area (Types A1, A2 and B1 only). This air is re-circulated through an additional HEPA filter prior to exhaust from the BSC. See the chart at the end of this section for specific capabilities and limits of the four types of Class II BSCs.

The Class II, Type A1 BSC (A) front opening; (B) sash; (C) exhaust HEPA filter; (D) supply HEPA filter; (E) common plenum; (F) blower.



The Class II, Type B1 BSC (bench top design) (A) front opening; (B) sash; (C) exhaust HEPA filter; (D) supply plenum; (E) supply HEPA filter; (F) blower; (G) negative pressure exhaust plenum. *Note:* The cabinet exhaust needs to be hard connected to the building exhaust system.

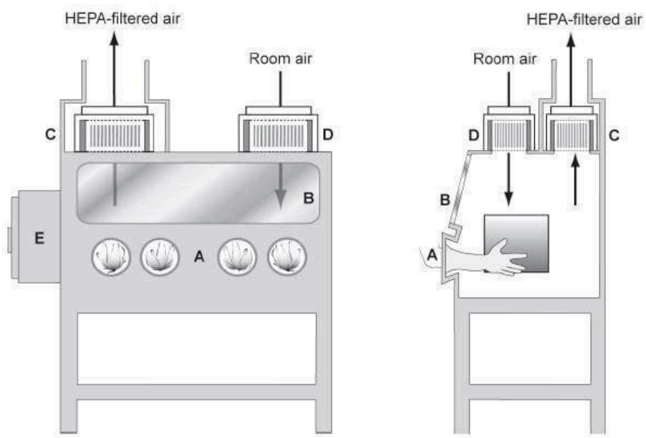
Connection to the building exhaust system is required.



4.2.4.3 Class III

The Class III BSC is designed for use with highly infectious microbiological agents. This BSC provides maximum protection to the lab personnel and the environment. The outward appearance is similar to that of a glove box. Material may be added or removed from the Class III BSC only through a double-pass door. The cabinet is kept under constant negative pressure through an exhaust system.

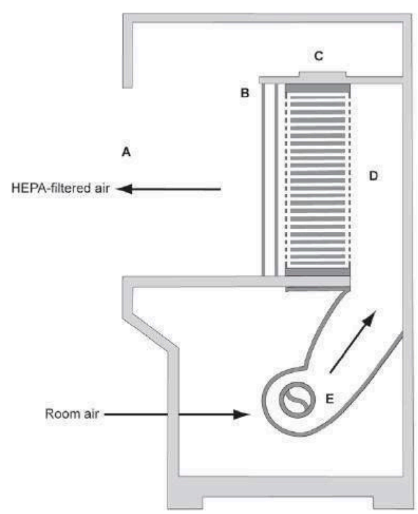
The Class III BSC (A) glove ports with O-ring for attaching arm-length gloves to cabinet; (B) sash; (C) exhaust HEPA filter; (D) supply HEPA filter; (E) double-ended autoclave or pass-through box. *Note:* A chemical dunk tank may be installed which would be located beneath the work surface of the BSC with access from above. The cabinet exhaust needs to be hard connected to an exhaust system where the fan is generally separate from the exhaust fans of the facility ventilation system. The exhaust air must be double HEPA-filtered or HEPA-filtered and incinerated.



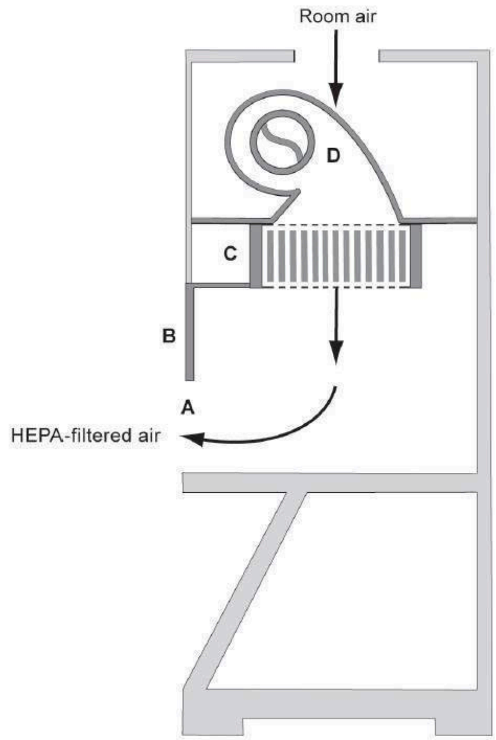
4.2.4.4 Laminar Flow and Vertical Flow "Clean Bench"

It is very important to note that both standard Laminar flow and Vertical flow cabinets are not Biosafety Cabinets. These two items do not provide protection to the worker, and should never be used when dealing with potentially infectious or harmful material.

The horizontal laminar flow "clean bench" (A) front opening; (B) supply grille; (C) supply HEPA filter; (D) supply plenum; (E) blower.



The vertical laminar flow "clean bench" (A) front opening; (B) sash; (C) supply HEPA filter; (D) blower. *Note:* Some vertical flow clean benches have recirculated air through front and/or rear perforated grilles.



4.2.4.5 *Selection and Comparison of BSCs*

The tables below are from BMBL and describe the type of BSC to be used with each biological risk and a comparison of BSC characteristics. The CDC has categorized biological risks into four Biosafety Levels (BSL). Detailed information on BSLs is addressed in *BMBL Edition 5*. The table below is from BMBL, page 59. It is important to note that Wake Forest University currently is not equipped for any work requiring BSL-3 or BSL-4. No agents are to be introduced to campus requiring these levels of protection.

4.3 Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) provides a physical barrier between a chemical or physical hazard and the wearer. In the laboratory, the main types of protective equipment are eyewear, gloves, and the lab coat.

NOTE ON RESPIRATORY PROTECTION: Since any work conducted that may result in vapors, fumes or dust is performed in the fume hood, respiratory protection would only be required on a case-by-case basis, and requires prior approval by the Department Chair and EHS.

4.3.1 Principal Investigator Responsibilities

It is the responsibility of the PI or designee to conduct a complete assessment to determine PPE requirements within the lab. A full review must be made of hazards that may require protection from both chemical and physical hazards. This review should be task specific, so that the requirements are known prior to beginning work. Proper PPE is to be provided to laboratory personnel at no cost to those personnel.

The PI or designee is also responsible for training those under their direction on the proper use and function of PPE. This includes identification of proper PPE for the hazard, donning and doffing PPE, decontamination (if applicable), and disposal.

The PI must ensure that lab personnel follow all PPE rules, and conduct an annual assessment to confirm the requirements are still applicable to hazards.

4.3.2 Lab Personnel Responsibilities

It is the responsibility of lab personnel to fully understand the hazards that require the use of PPE, both chemical and physical. Training must be completed prior to working in the lab. It is the responsibility of the lab personnel to use the proper PPE in a proper manner whenever working in the lab.

4.3.3 Eye Protection

Eye protection is required at all times in the laboratory and where hazards to the eye may exist. This includes splashes, sprays, aerosols, dust, powder, fumes and vapor. Safety glasses with side shields are appropriate for situations where there is no risk of fumes or vapors. In cases where fumes or vapors may be present, safety goggles must be worn, as these provide much better protection against these hazards.

4.3.3.1 Chemical Splash Goggles

Chemical splash goggles provide excellent overall eye protection against splashes, vapors and flying debris. Goggles must be worn when there is a significant chemical or debris hazard, and are recommended for use over safety glasses in all laboratories. Be sure the goggles are indirectly vented, as this will inhibit fumes and vapors from entering the goggles.

4.3.3.2 Safety Glasses

Safety glasses with side shields afford the minimum protection for use in the lab. Safety glasses are available that will fit over prescription glasses. Standard prescription glasses are not a substitute for safety glasses. Prescription glasses with safety lenses must also have side shields.

4.3.3.3 Full Face Shield and Blast Shield

The full face shield is worn in addition to safety glasses or goggles when the chance for exposure to splashes or debris is great. The full face shield is designed to provide protection to the entire face and neck.

The blast shield is also used in addition to safety glasses or goggles. The blast shield is to be used in situations where there is the chance of implosion or explosion (i.e. working with azides). The shield is intended for protection of only that part of the body behind the shield. Peering over the top of the blast shield will not afford protection to the head. It must be behind the shield at all times.

4.3.3.4 Eye Protection from UV radiation

Ultraviolet (UV) radiation can damage skin and eyes. In the lab, common sources of UV radiation are UV light boxes or UV Transilluminator, UV Crosslinkers, and Germicidal Lamps. Eye exposure to UV radiation can damage the cornea and cause lesions. Standard prescription eyewear, standard safety glasses, and goggles do not protect against UV radiation.

Protective eyewear must be ANSI-Z87 rated to provide proper UV protection. This marking will be stamped onto the eyewear, typically on the side shield. Contact the safety glass manufacturer before you use the protective eyewear if you are unsure.

4.3.3.5 Eye Protection from Lasers

The focused energy of lasers has the ability to cause corneal, lens and retinal damage to the eye. It is important to note that no single safety lens material is effective against all wavelengths or for all radiation. Protective eyewear should provide maximum attenuation of the laser and transmit the maximum amount of ambient light. When choosing protective eyewear consider the parameters of the operation, the wavelength and the Maximum Permissible Exposure (MPE). The MPE has been set by ANSI Z136.1. See the WFU Laser Safety Manual for more information.

4.3.4 Skin and Hand Protection

Proper attire in the laboratory is essential to prevent skin exposure from chemical or physical hazards. In addition, the proper type of glove must be used for the appropriate hazard.

4.3.4.1 Proper clothing

Always wear clothing that adequately covers the torso and legs. **Shorts are not permitted in the lab.** Loose clothing should not be worn as it could easily become caught on equipment, come in contact with chemicals or catch fire. Natural fiber clothing is recommended over synthetic fiber, as synthetic fiber will melt to the body in the event it catches fire. **Open toe and open top shoes are prohibited in the lab.** Always wear shoes that cover the entire foot, and preferably have a rubber non-slip sole.

4.3.4.1.1 Lab Coats

A lab coat should be worn as an additional layer of protection. In the event of a spill or fire, the lab coat can be removed much more quickly than any other article of clothing, and will offer a degree of protection to the clothing beneath. Disposable lab coats are available at the Bookstore, as are cotton fiber standard lab coats. Be aware that unless specifically marked, lab coats are not protected against fire. Individuals working with pyrophoric and flammable liquids on a regular basis should consider using a lab coat that is flame resistant.

4.3.4.2 Gloves

Gloves should never be worn outside of the laboratory unless required for safety reasons (i.e. transporting autoclaved material). Never touch items with gloves that will be touched with ungloved hands. This includes light switches, elevator buttons, computers, and phones.
All approved disposable glove manufacturers have tested glove “breakthrough” time for their respective products. The breakthrough time indicates the time, usually in minutes, the glove can be exposed to a specific chemical before the glove begins to break down and become porous. Charts with breakthrough times are available from each manufacturer and are usually located on their website. Be sure you have the correct chart for the glove manufacturer, as each will be unique to its own products.

4.3.4.2.1 Nitrile Gloves

Nitrile gloves generally provide the best overall protection for the widest range of chemicals. Be sure to blow into the glove before use to check for pinhole leaks. When removing disposable Nitrile gloves, be sure not to touch exposed skin with the gloved fingertips. Turn gloves inside out when removing. Disposable nitrile gloves are never to be re-used, and should be replaced on a regular basis even if there is no obvious deterioration.

4.3.4.2.2 Neoprene Gloves

Neoprene gloves offer greater protection than Nitrile gloves, and should be used when working with concentrated, highly corrosive or toxic materials. Neoprene is not as pliable as Nitrile, and extra care should be taken when used, as dexterity will be lessened.

4.3.4.2.3 Temperature Resistant Gloves

When working with extremes of heat and cold it is important to protect hands from burns. This would include when working with boiling or superheated liquids (as from an autoclave) or when working with cryogenics (liquid Nitrogen or Dry Ice). Heat-resistant Neoprene gloves are a good choice when handling hot glassware and boiling liquids. Specific cryogenic gloves are to be used whenever using liquid nitrogen. This includes when disbursing from large cylinders into dewars. Cryogenic gloves should also be used when adding or removing material from sub-zero freezers.

4.3.5 Respiratory Protection

Engineering controls are in place to protect lab personnel from contaminants that may exceed Permissible Exposure Limits (PELs) or other applicable standards. If conditions exist where effective engineering controls are not possible, proper respiratory protection must be provided. These conditions should be very rare, and prior to working under such conditions notification must be made to the Department Chair and EHS so an analysis can be made to determine if additional engineering controls may be put in place to avoid the use of respiratory protection.

It should be noted that N-95 Face Masks are considered respirators under OSHA. Required use of a Face Mask to protect from airborne particulates will necessitate notification to the Department Chair and EHS.

4.3.5.1 Permissible Exposure Limits (PELs)

OSHA sets PELs to protect workers against exposure to airborne hazardous substances. In some cases PELs may also be set for skin exposure. The OSHA PEL is based on an 8-hour time weighted average (TWA) exposure, above which lab personnel may not exceed. The list of chemicals with a specific PEL may be found at:

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992

This list is published in 29 CFR 1910.1000 Table Z-1.

4.3.5.2 Medical Evaluation and Respiratory Protection Program

Prior to wearing a respirator, the lab worker must complete a medical evaluation questionnaire to determine fitness to wear the respirator. Any individual required to wear a respirator must be enrolled in the University Respiratory Protection Program. This program is administered by EHS. All medical evaluations and program training must be completed prior to using a respirator.

5. GUIDELINES FOR WORKING WITH HAZARDOUS MATERIALS

Under the CDC, the National Institute of Occupational Safety and Health (NIOSH) has published the NIOSH Pocket Guide to Chemical Hazards. This is an excellent reference for physical and health hazards of 677 distinct chemicals. This guide also lists OSHA Permissible Exposure Limits.

5.1 Globally Harmonized System of Classification and Labeling of Chemicals

The Globally Harmonized System of Classification and Labeling (GHS) includes criteria for classifying health, physical and environmental hazards. GHS specifies information that must be included on hazardous chemical labels and on Safety Data Sheets (SDS).

5.1.1 Physical Hazards

Physical hazards described in GHS are typically quantitative with a distinct endpoint. Below is a listing of the physical hazards, followed by a brief description of each. Note that some hazards (e.g. flammable liquids, pyrophorics) have multiple categories based on severity of the hazard. Familiarization with these hazards is required to work safely in the lab.

Hazard	Category	Criteria
Explosives		solid or liquid which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gases.
Flammable Gases		a gas having a flammable range in air at 20°C and a standard pressure of 101.3 kPa.
Flammable Aerosols		any gas compressed, liquefied or dissolved under pressure within a non-refillable container.
Oxidizing Gases		any gas which may, generally by providing oxygen, cause or contribute to the combustion of other material more than air does.
Gases under Pressure		gases that are contained in a receptacle at a pressure not less than 280 Pa at 20°C or as a refrigerated liquid.
Flammable Liquids		Flammable liquid means a liquid having a flash point of not more than 93°C.
	1	Flash point < 23°C and initial boiling point ≤ 35°C (95°F)
	2	Flash point < 23°C and initial boiling point > 35°C (95°F)
	3	Flash point ≥ 23°C and ≤ 60°C (140°F)
	4	Flash point ≥ 60°C (140°F) and ≤ 93°C (200°F)
Flammable Solids		solids that are readily combustible, or may cause or contribute to fire through friction.
	1	Metal Powders: burning time ≤ 5 minutes: Others: wetted zone does not stop fire & burning time < 45 seconds or burning > 2.2 mm/second
	2	Metal Powders: burning time > 5 and ≤ 10 minutes; Others: wetted zone stop fire for at least 4 minutes & burning time < 45 seconds or burning rat > 2.2mm/second
Self-Reactive Substances		thermally unstable liquids or solids liable to undergo a strongly exothermic thermal decomposition even without participation of oxygen (air).
	A	Can detonate or deflagrate rapidly, as packaged.
	B	Possess explosive properties and which, as packaged, neither detonates nor deflagrates, but is liable to undergo a thermal explosion in that package.
	C	Possess explosive properties when the substance or mixture as package cannot detonate or deflagrate rapidly or undergo a thermal explosion.
	D	Detonates partially, does not deflagrate rapidly and shows no violent effect when heated under confinement; or Does not detonate at all, deflagrates slowly and shows no violent effect when heated under confinement; or Does not detonate or deflagrate at all and shows a medium effect when heated under confinement.
	E	Neither detonates nor deflagrates at all and shows low or no effect when heated under confinement.
	F	Neither detonates in the cavitated bubble state nor deflagrates at all and shows only a low or no effect when heated under confinement as well as low or no explosive power.
	G	Neither detonates in the cavitated state nor deflagrates at all and shows non effect when heated under confinement nor any explosive power, provided that it is thermally stable (self-accelerating decomposition temperature is 60°C to 75°C for a 50 kg package), and, for liquid mixtures, a diluent having a boiling point not less than 150°C is used for desensitization.
Pyrophoric Liquids		a liquid which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.
Pyrophoric Solids		a solid which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.
Self-Heating Substances		a solid or liquid, other than a pyrophoric substance, which, by reaction with air and without energy supply, is liable to self-heat.
Substances which on Contact with Water Emit Flammable Gases		Substances that, in contact with water, emit flammable gases are solids or liquids which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.
	1	≥10 L/kg/1 minute gas evolution
	2	≥20 L/kg/ 1 hour + < 10 L/kg/1 min gas evolution
	3	≥1 L/kg/1 hour + < 20 L/kg/1 hour gas evolution
	No Class	< 1 L/kg/1 hour gas evolution
Oxidizing Liquids		a liquid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause or contribute to the combustion of other material.
Oxidizing Solids		a solid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause or contribute to the combustion of other material.
Organic Peroxides		organic liquid or solid which contains the bivalent -0-0- structure and may be considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals.
	A	Can detonate or deflagrate rapidly, as packaged.
	B	Possess explosive properties and which, as packaged, neither detonates nor deflagrates, but is liable to undergo a thermal explosion in that package.
	C	Possess explosive properties when the substance or mixture as package cannot detonate or deflagrate rapidly or undergo a thermal explosion.
	D	Detonates partially, does not deflagrate rapidly and shows no violent effect when heated under confinement; or Does not detonate at all, deflagrates slowly and shows no violent effect when heated under confinement; or Does not detonate or deflagrate at all and shows a medium effect when heated under confinement.
	E	Neither detonates nor deflagrates at all and shows low or no effect when heated under confinement.
	F	Neither detonates in the cavitated bubble state nor deflagrates at all and shows only a low or no effect when heated under confinement as well as low or no explosive power.
	G	Neither detonates in the cavitated state nor deflagrates at all and shows non effect when heated under confinement nor any explosive power, provided that it is thermally stable (self-accelerating decomposition temperature is 60°C to 75°C for a 50 kg package), and, for liquid mixtures, a diluent having a boiling point not less than 150°C is used for desensitization.
Substances Corrosive to Metal		A substance or a mixture that by chemical action will materially damage, or even destroy, metals is termed 'corrosive to metal'.

5.1.2 Health Hazards and Toxicity

The following tables describe health and toxicity information that will be found on chemical labels and SDS.

5.1.2.1 Acute Toxicity

For purposes of GHS, acute toxicity is based on lethal dose - LD_{50} (oral, dermal) or lethal concentration - LC_{50} (inhalation), indicating the amount of the substance required (usually per body weight) to kill 50% of the test population.

Acute Toxicity

<table>
<tr><th>Acute toxicity</th><th>Cat. 1</th><th>Cat. 2</th><th>Cat. 3</th><th>Cat. 4</th><th>Category 5</th></tr>
<tr><td>Oral (mg/kg)</td><td>≤ 5</td><td>> 5
≤ 50</td><td>> 50
≤ 300</td><td>> 300
≤ 2000</td><td rowspan="5">Criteria:
• Anticipated oral LD50 between 2000 and 5000 mg/kg;
• Indication of significant effect in humans;*
• Any mortality at class 4;*
• Significant clinical signs at class 4;*
• Indications from other studies.*
*If assignment to more hazardous class is not warranted.</td></tr>
<tr><td>Dermal (mg/kg)</td><td>≤ 50</td><td>> 50
≤ 200</td><td>> 200
≤ 1000</td><td>> 1000
≤ 2000</td></tr>
<tr><td>Gases (ppm)</td><td>≤ 100</td><td>> 100
≤ 500</td><td>> 500
≤ 2500</td><td>> 2500
≤ 5000</td></tr>
<tr><td>Vapors (mg/l)</td><td>≤ 0.5</td><td>> 0.5
≤ 2.0</td><td>> 2.0
≤ 10</td><td>> 10
≤ 20</td></tr>
<tr><td>Dust & mists (mg/l)</td><td>≤ 0.05</td><td>> 0.05
≤ 0.5</td><td>> 0.5
≤ 1.0</td><td>> 1.0
≤ 5</td></tr>
</table>

5.1.2.2 Skin Corrosion

Skin corrosion indicates irreversible damage to the skin following the application of a test substance for up to 4 hours.

Skin Corrosion / Irritation

<table>
<tr><th colspan="3">Skin Corrosion
Category 1</th><th>Skin Irritation
Category 2</th><th>Mild Skin Irritation
Category 3</th></tr>
<tr><td colspan="3">Destruction of dermal tissue: visible necrosis in at least one animal</td><td rowspan="2">Reversible adverse effects in dermal tissue

Draize score: ≥ 2.3 < 4.0
or persistent inflammation</td><td rowspan="2">Reversible adverse effects in dermal tissue

Draize score: ≥ 1.5 < 2.3</td></tr>
<tr><td>Subcategory 1A
Exposure < 3 min.
Observation < 1hr,</td><td>Subcategory 1B
Exposure < 1hr.
Observation < 14 days</td><td>Subcategory 1C
Exposure < 4 hrs.
Observation < 14 days</td></tr>
</table>

5.1.2.3 Eye Effects

Serious eye damage includes tissue damage or deterioration of vision after exposure to the substance, which is not fully reversible in 21 days.

Eye Effects

Category 1 **Serious eye damage**	Category 2 **Eye Irritation**	
Irreversible damage 21 days after exposure Draize score: Corneal opacity ≥ 3 Iritis > 1.5	Reversible adverse effects on cornea, iris, conjunctiva Draize score: Corneal opacity ≥ 1 Iritis > 1 Redness ≥ 2 Chemosis ≥ 2	
	Irritant Subcategory 2A Reversible in 21 days	**Mild Irritant** Subcategory 2B Reversible in 7 days

5.1.2.4 *Mutagenicity and Carcinogenicity*

Mutagens are agents that may increase the occurrence of cellular mutation. Carcinogens are substances which will induce, or increase the incidence, of cancer.

Germ Cell Mutagenicity

Category 1 **Known/Presumed**		Category 2 **Suspected/Possible**
Known to produce heritable mutations in human germ cells		• May include heritable mutations in human germ cells • Positive evidence from tests in mammals and somatic cell tests • *In vivo* somatic genotoxicity supported by *in vitro* mutagenicity
Subcategory 1A Positive evidence from epidemiological studies	Subcategory 1B Positive results in: • *In vivo* heritable germ cell tests in mammals • Human germ cell tests • *In vivo* somatic mutagenicity tests, combined with some evidence of germ cell mutagenicity	

Carcinogenicity

Category 1 **Known or Presumed Carcinogen**		Category 2 **Suspected Carcinogen**
Subcategory 1A **Known Human Carcinogen** Based on human evidence	Subcategory 1B **Presumed Human Carcinogen** Based on demonstrated animal carcinogenicity	Limited evidence of human or animal carcinogenicity

5.1.2.5 *Reproductive Toxicity*

Reproductive toxins cause adverse effects on fertility and sexual function in males and females, as well as in offspring.

Reproductive Toxicity

Category 1		Category 2 **Suspected**	**Additional Category**
Known or presumed to cause effects on human reproduction or on development		Human or animal evidence possibly with other information	Effects on or via lactation
Category 1A **Known** Based on human evidence	**Category 1B** **Presumed** Based on experimental animals		

5.1.3 Pictograms and Signal Words

GHS hazard symbols will appear on chemical labels and on SDS. In addition, hazard statements describe the hazard by hazard classification. Signal words will indicate the severity of a hazard, where:

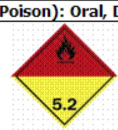
"Danger" indicates more severe hazards, and

"Warning" indicates less severe hazards.

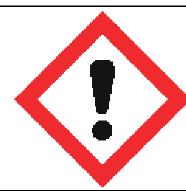
Below are the GHS pictograms that will appear on chemical labels with designated signal words beneath. Lab personnel need to be familiar with the pictograms and associated hazards.

GHS Pictograms and Hazard Classes		
		
▪ Oxidizers	▪ Flammables ▪ Self Reactives ▪ Pyrophorics ▪ Self-Heating ▪ Emits Flammable Gas ▪ Organic Peroxides	▪ Explosives ▪ Self Reactives ▪ Organic Peroxides
		
▪ Acute toxicity (severe)	▪ Corrosives	▪ Gases Under Pressure
		
▪ Carcinogen ▪ Respiratory Sensitizer ▪ Reproductive Toxicity ▪ Target Organ Toxicity ▪ Mutagenicity ▪ Aspiration Toxicity	▪ Environmental Toxicity	▪ Irritant ▪ Dermal Sensitizer ▪ Acute toxicity (harmful) ▪ Narcotic Effects ▪ Respiratory Tract ▪ Irritation

Packages arriving on campus may bear GHS transportation pictograms. The outer packing of the box may contain one or more of these to indicate hazard(s). Below are the pictograms used in transporting hazardous material.

Transport "Pictograms"		
		
Flammable Liquid Flammable Gas Flammable Aerosol	**Flammable solid Self-Reactive Substances**	**Pyrophorics (Spontaneously Combustible) Self-Heating Substances**
		
Substances, which in contact with water, emit flammable gases (Dangerous When Wet)	**Oxidizing Gases Oxidizing Liquids Oxidizing Solids**	**Explosive Divisions 1.1, 1.2, 1.3**
		
Explosive Division 1.4	**Explosive Division 1.5**	**Explosive Division 1.6**
		
Compressed Gases	**Acute Toxicity (Poison): Oral, Dermal, Inhalation**	**Corrosive**
		
Marine Pollutant	**Organic Peroxides**	

Acute Oral Toxicity is divided into five categories dependent on the LD (Lethal Dose)$_{50}$. The LD_{50} is the amount of the substance required (usually per body weight) to kill 50% of the test population.

ACUTE ORAL TOXICITY - Annex 1					
	Category 1	**Category 2**	**Category 3**	**Category 4**	**Category 5**
LD_{50}	£ 5 mg/kg	> 5 < 50 mg/kg	³ 50 < 300 mg/kg	³ 300 < 2000 mg/kg	³ 2000 < 5000 mg/kg
Pictogram					No symbol
Signal word	Danger	Danger	Danger	Warning	Warning
Hazard statement	Fatal if swallowed	Fatal if swallowed	Toxic if swallowed	Harmful if swallowed	May be harmful if swallowed

5.1.4 Safety Data Sheets

The University uses the online SDS database ChemWatch. This is also the chemical inventory management system. Access is available to all WFU employees, faculty and staff. It can be accessed on the EHS website.

The Safety Data Sheet (SDS) provides detailed information for chemical management. The SDS is to be used by lab personnel as a source of information regarding hazards and safety precautions for the particular chemical. The SDS will contain 16 headings, as shown in the chart below. These headings will be the same on every SDS.

Minimum information for an SDS

1.	**Identification of the substance or mixture and of the supplier**	▪ GHS product identifier. ▪ Other means of identification. ▪ Recommended use of the chemical and restrictions on use. ▪ Supplier's details (including name, address, phone number, etc.). ▪ Emergency phone number.
2.	**Hazards identification**	▪ GHS classification of the substance/mixture and any national or regional information. ▪ GHS label elements, including precautionary statements. (Hazard symbols may be provided as a graphical reproduction of the symbols in black and white or the name of the symbol, e.g., flame, skull and crossbones.) ▪ Other hazards which do not result in classification (e.g., dust explosion hazard) or are not covered by the GHS.
3.	**Composition/information on ingredients**	**Substance** ▪ Chemical identity. ▪ Common name, synonyms, etc. ▪ CAS number, EC number, etc. ▪ Impurities and stabilizing additives which are themselves classified and which contribute to the classification of the substance. **Mixture** ▪ The chemical identity and concentration or concentration ranges of all ingredients which are hazardous within the meaning of the GHS and are present above their cutoff levels. ***NOTE****: For information on ingredients, the competent authority rules for CBI take priority over the rules for product identification.*
4.	**First aid measures**	▪ Description of necessary measures, subdivided according to the different routes of exposure, i.e., inhalation, skin and eye contact, and ingestion. ▪ Most important symptoms/effects, acute and delayed. ▪ Indication of immediate medical attention and special treatment needed, if necessary.
5.	**Firefighting measures**	▪ Suitable (and unsuitable) extinguishing media. ▪ Specific hazards arising from the chemical (e.g., nature of any hazardous combustion products). ▪ Special protective equipment and precautions for firefighters.
6.	**Accidental release measures**	▪ Personal precautions, protective equipment and emergency procedures. ▪ Environmental precautions. ▪ Methods and materials for containment and cleaning up.

7.	**Handling and storage**	▪ Precautions for safe handling. ▪ Conditions for safe storage, including any incompatibilities.
8.	**Exposure controls/personal protection.**	▪ Control parameters, e.g., occupational exposure limit values or biological limit values. ▪ Appropriate engineering controls. ▪ Individual protection measures, such as personal protective equipment.
9.	**Physical and chemical properties**	▪ Appearance (physical state, color, etc.). ▪ Odor. ▪ Odor threshold. ▪ pH. ▪ melting point/freezing point. ▪ initial boiling point and boiling range. ▪ flash point. ▪ evaporation rate. ▪ flammability (solid, gas). ▪ upper/lower flammability or explosive limits. ▪ vapor pressure. ▪ vapor density. ▪ relative density. ▪ solubility(ies). ▪ partition coefficient: n-octanol/water. ▪ autoignition temperature. ▪ decomposition temperature.
10.	**Stability and reactivity**	▪ Chemical stability. ▪ Possibility of hazardous reactions. ▪ Conditions to avoid (e.g., static discharge, shock or vibration). ▪ Incompatible materials. ▪ Hazardous decomposition products.
11.	**Toxicological information**	Concise but complete and comprehensible description of the various toxicological (health) effects and the available data used to identify those effects, including: ▪ information on the likely routes of exposure (inhalation, ingestion, skin and eye contact); ▪ Symptoms related to the physical, chemical and toxicological characteristics; ▪ Delayed and immediate effects and also chronic effects from short- and long-term exposure; ▪ Numerical measures of toxicity (such as acute toxicity estimates).
12.	**Ecological information**	▪ Ecotoxicity (aquatic and terrestrial, where available). ▪ Persistence and degradability. ▪ Bioaccumulative potential. ▪ Mobility in soil. ▪ Other adverse effects.
13.	**Disposal considerations**	▪ Description of waste residues and information on their safe handling and methods of disposal, including the disposal of any contaminated packaging.

14.	**Transport information**	▪ UN Number. ▪ UN Proper shipping name. ▪ Transport Hazard class(es). ▪ Packing group, if applicable. ▪ Marine pollutant (Yes/No). ▪ Special precautions which a user needs to be aware of or needs to comply with in connection with transport or conveyance either within or outside their premises.
15.	**Regulatory information**	▪ Safety, health and environmental regulations specific for the product in question.
16.	**Other information including information on preparation and revision of the SDS**	

5.2 Chemical Labeling

Chemical labeling is a vital component of laboratory safety. Unlabeled, mislabeled, and poorly labeled containers can lead to unintended and often dangerous consequences.

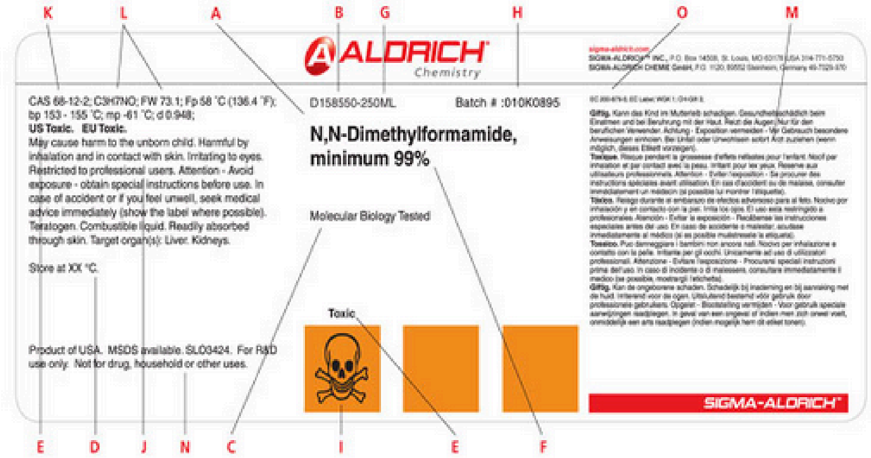
5.2.1 Chemicals in Original Containers

Chemicals in their original containers will be labeled by the manufacturer prior to shipment. Manufacturer label must remain visible and is not to be removed from the bottle while the product still remains. If a label becomes defaced or otherwise illegible it is to be replaced. The replacement label must at a minimum contain the following:

- Chemical name
- Hazard(s)
- Manufacturer
- Manufacturer address and phone number

Below is an example of a manufacturer product label, with identification of each component.

Key to Aldrich Product Labels:



A Product Name and Description

B Product Number

C Further Descriptive Information

D Recommendations on Handling and Storage
Storage temperatures indicated are for long-term storage of products. Products may be shipped under different conditions to reduce shipping costs, while still ensuring product quality.

E Hazard Statement
Indication of danger.

F Lot Analysis
Data on activity, purity, degree of hydration, etc., for this lot.

G Package Size
Unless the material is described as pre-weighed, the package will normally contain at least the indicated quantity, and usually somewhat more. For some products, the actual quantity at time of packaging is also shown. The user should always measure the amount needed from the container.

H Lot Number

I Hazard Pictogram
Lets you know at a glance what safety hazards are involved in the use of this product.

J Further Hazard Information
More complete description of actual hazards, handling precautions, and emergency management procedures.

K CAS Number
Chemical Abstract Service number shown wherever available. CAS numbers vary in how specifically they define the material. We make every effort to provide the most specific CAS number which applies. Where a CAS number is provided for a mixture or solution, it is usually the CAS number of the solute or component referred to in the main label name.

L Chemical Formula and Formula Weight
Unless water of hydration is indicated in the formula, the formula weight is for the anhydrous material.

M Risk and Safety Statements:
Information is provided in multiple languages.

N Material Safety Data Sheet Available:
A Material Safety Data Sheet is available for this product.

O EC Number:
EC Number (EINECS or ELINCS), products without an EINECS number will carry the warning statement, "Caution: Substance Not Yet Fully Tested."

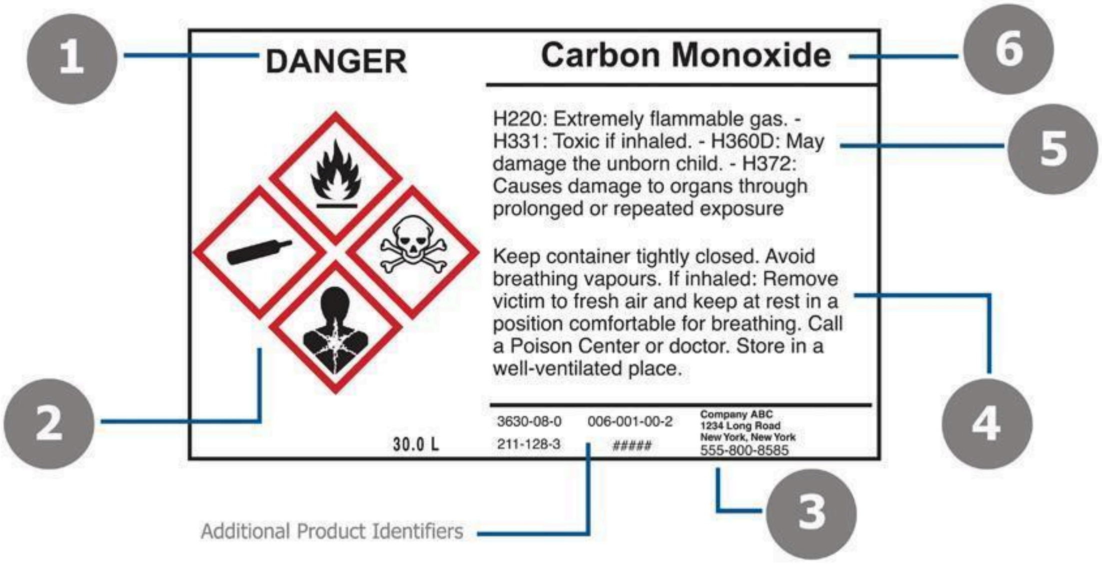
5.2.2 Chemicals Transferred from Original Container

Chemicals transferred from their original container must be labeled with:

- THE IDENTITY OF THE CHEMICAL AND APPROPRIATE HAZARD WARNINGS MUST BE SHOWN ON THE LABEL.
- HAZARD PICTOGRAM
- THE NAME AND ADDRESS OF THE MANUFACTURER OR OTHER RESPONSIBLE PARTY MUST BE INCLUDED ON THE LABEL.

- THE HAZARD LABEL MESSAGE MUST BE LEGIBLE, PERMANENTLY DISPLAYED AND WRITTEN IN ENGLISH.

Make sure that labels and ink are not soluble with the contents of the container. An example of this type of label is shown below.



5.2.3 Stock Solutions

Stock solutions must be labeled in a manner similar to that of chemicals transferred from their original container. In this case, the chemical name will be the name of the stock solution (e.g. 1XPBS, 2N HCl, 1M NaOH.) Abbreviations may only be used if the stock solution abbreviation is known to all lab personnel. Otherwise, the full chemical name must be displayed. Please note: a list of common acceptable abbreviations is listed in Appendix II.
It is of benefit if the hazard(s) also be identified on the label. Appropriate identification would be to add the signal word, or pictogram label with matching signal word to the container, as in the example below.

5.2.4 Samples and Prepared Chemical Substances

Samples and other prepared substances should be identifiable by lab personnel. This is especially true if:

- The material is not used within the work shift of the individual who prepares the sample or substance.
- The worker who made the sample or substance leaves the work area.

- The container with the sample or substance is moved to another work area and is no longer in the possession of the preparer.

The use of a laboratory notebook is acceptable as means of identification as long as individual samples or compounds can be identified through a numbering or other marking system that will allow the user or other lab personnel to match the sample with the information in the notebook identifying the contents of said sample or compound. The lab notebook must be accessible when the preparer is not present in the lab to allow other lab personnel to identify contents.

5.3 Laboratory Signs

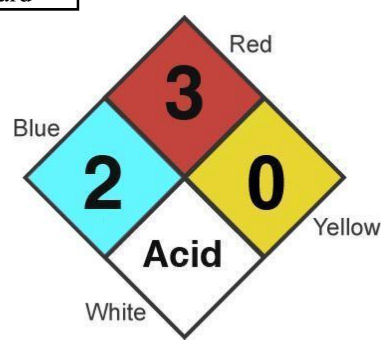
Signs in and around laboratories are in place as a means of quick identification of potential hazards, means of egress, and location of safety equipment. It is the responsibility of the PI to ensure that all appropriate signs are posted within the lab, and that these are visible and legible. EHS can assist with obtaining and placement of signs.

5.3.1 National Fire Protection Agency (NFPA)

The NFPA 704 Diamond Label system is used to inform building occupants and first responders of potential chemical and physical hazards within a building. The system uses three specific categories to identify flammability, health and reactivity hazard levels. A fourth category identifies special hazards that are present.

The label is color coded red, blue, yellow and white to highlight different hazards, making it easier to identify specific risks. NFPA 704 uses a numerical value of between “0” and “4” to indicate the relative level of hazard for that particular chemical. In this system, a rating of “0” indicates little or no risk, while a rating of “4” indicates the highest or most severe risk. An example is shown below.

Color	Category
Blue	Health
Red	Flammability
Yellow	Reactivity
White	Special Hazard



Number	Flammability	Health Hazard	Reactivity
0	Material will not burn	No Hazard	Not Reactive
1	Material must be exposed to high heat before ignition occurs; flash point >200 ^{o} F	Minor irritation	Normally stable but can become unstable w/ heat
2	Moderate heat required before ignition occurs; flash point 100-200 ^{o} F	Intense or chronic exposure may cause temporary incapacitation	Violent reaction when exposed to heat or w/ water

3	Liquids or solids that ignite under ambient temperatures; flash point <100° F	Short exposure could cause serious injury	May detonate w/ initiating source or reacts w/ water
4	Vaporizes and burns at normal temp/pressure; flash point <73° F (rm. temp.)	Short exposure could cause death	May detonate at normal temp/pressure

The white diamond on the bottom lists special properties.

- ACID (strong acid, usually a mineral acid)
- ALK (strong alkali)
- COR (strong corrosive)
- OXY (strong oxidizer)
- P (can polymerize spontaneously and release energy)
- ~~W~~ (use no water)

5.3.2 NFPA vs. GHS

It is very important to note that NFPA and GHS hazard category number systems do not align. As shown in section A. 1 above, the GHS numerical system of hazard severity uses the number "1" as most severe. In most cases, the GHS numerical system will only be seen on the SDS. Signs posted in the lab will use the NFPA 704 system, since this will support not only lab personnel, but first responders in the event of an emergency.

5.3.3 Space Hazard Signs

Each laboratory door is marked with a Space Hazard Sign. The Space Hazard Sign indicates the chemical and physical hazards present within the space, and includes emergency contact information. These signs were developed by EHS with the assistance of each PI. It is the PI's responsibility to ensure the information on the Space Hazard Sign is correct. Any changes to chemical or physical hazards in the lab will be provided to EHS so an updated sign can be created.

5.3.4 Exit Signs, Emergency Equipment Signs, Evacuation Signs

Exit signs are posted throughout each building. Exit signs are backlit to provide visibility in the event of a power outage. Always know the location of at least two exits from a building. This allows for a safe evacuation from a building in the event the primary exit is blocked.
Emergency equipment signs are posted to identify the location of safety showers, eyewash stations, and fire extinguishers. If a sign is missing or has become illegible, notify F&CS Customer Service at x4255 for replacement.
Building evacuation signs are posted in the hallways of each building. When entering any building, take note of the evacuation signs to locate the nearest exit and the evacuation route. This information is an essential life-saving tool in the event of an emergency requiring building evacuation.

5.4 Chemical Storage

Chemical storage considerations are dependent on a number of factors. Several federal, state and local regulations affect handling and storage of chemicals in laboratories. These include restrictions on storage of consumable alcohol, flammable material, and controlled substances.

5.4.1 Incompatibles

Incompatible materials must never be stored together. There must be at least a separation of distance that will prohibit unintentional mixing in the event of release. Preferably, incompatibles are to be separated within different storage areas or separated by means of secondary containment.

5.4.2 Flammable Liquids

The Winston-Salem Fire Department defines strict limitations to the amount of flammable liquids that may be stored on each building level. With each increase in building floor there is a corresponding decrease in the quantity of flammables that may be stored. The Wake Forest University Fire and Life Safety Specialist in F&CS will provide each building the information on maximum storage quantities per floor of flammable liquids.

5.4.3 Controlled Substances

Controlled substances are regulated by the US Department of Justice Drug Enforcement Agency (USDOJ DEA). Information regarding storage requirements for controlled substances is located in the Wake Forest University *Guidelines: Use of Controlled Substances in Research*. This document provides detailed information on the registration process, procurement, storage, and use of controlled substances at the University. Security of controlled substances is essential in preventing illegal diversion.

5.4.4 Consumable Alcohol used in Research

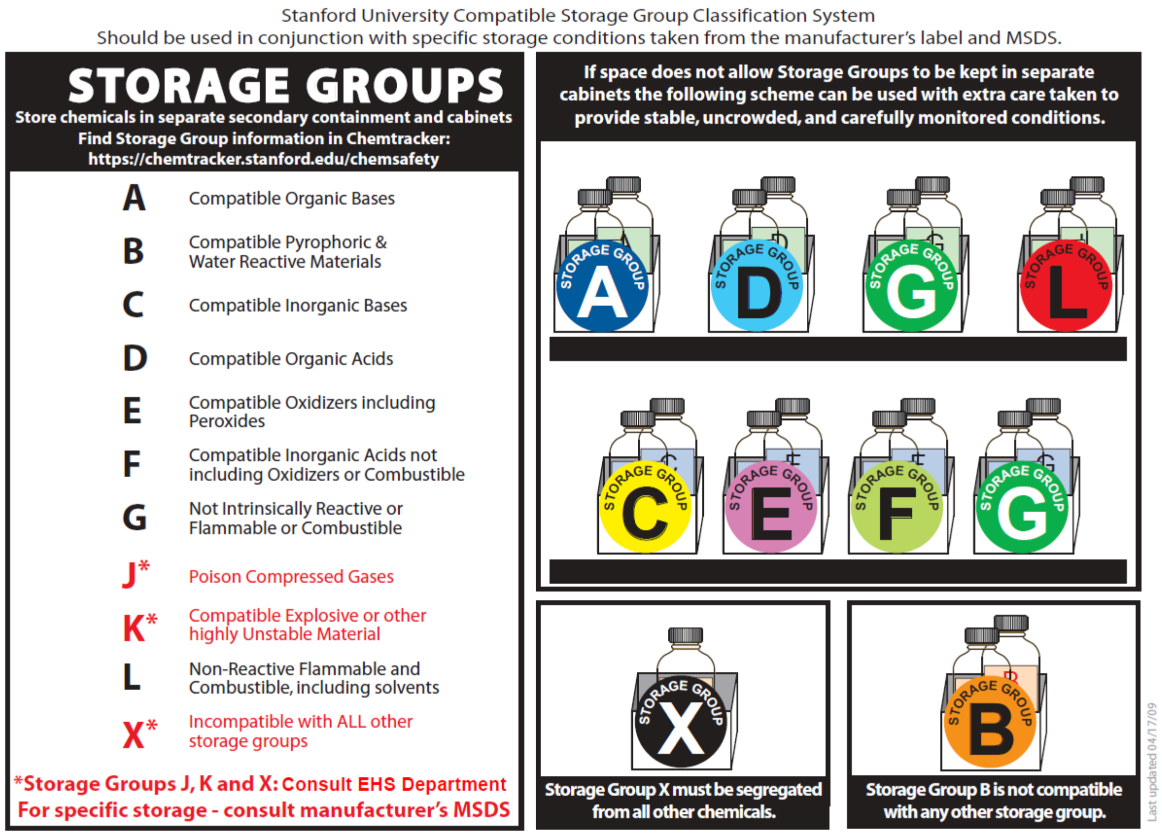
Wake Forest University maintains a single license from the Department of Justice Bureau of Alcohol, Tobacco, Firearms and Explosives (DOJ ATF) for the purchase of consumable alcohol used in research. The license is necessary for purchase of alcohol, and therefore is controlled by the University Administration.

5.4.5 Storage Guidelines

Prudent Practices provides detailed information on chemical storage within laboratories and stockrooms. The information is located in Chapter 5, Section E, and should be reviewed to ensure proper storage methods are being employed in the lab. General considerations for storage include:

- Avoiding chemical storage above eye-level,
- Storing frequently used chemicals within easy reach,
- Storing heavy materials on lower shelves, and
- Prohibiting storage on floors or in areas that block egress or where chemicals may be inadvertently knocked over.

The following list is from Prudent Practices (page 97) and lists examples of compatible storage groups:



5.5 Waste Collection, Labeling and Disposal of Chemical Waste

The Environmental Protection Agency (EPA) governs the regulations regarding collection and disposal of chemical waste. A substance in the lab is considered a waste when it will no longer be used for its original purpose and / or is no longer needed in the laboratory.

5.5.1 Hazardous Waste Descriptions

Hazardous waste is dangerous or potentially harmful to health and the environment. Hazardous wastes may be liquid, sludges, solids, or gases. Four main classifications of hazardous waste have been developed by the EPA: flammable, corrosive, reactive and toxic.

5.5.1.1 Flammable Waste

Flammable wastes include liquids with a flash point of less than 140 ^{o}F, oxidizers (liquid or solid), solids that may ignite due to friction, water-reactive materials, and spontaneously combustible materials. Flammable compressed gases also fall under this category. Some examples of common flammable waste include:

- Unused or spent organic solvents or alcohols (acetone, THF, ethanol, isopropyl alcohol)
- Peroxides, perchlorates, permanganates, hypochlorites
- Full, partial full or empty lecture cylinders of propane or hydrogen

5.5.1.2 Corrosive Waste

Corrosive wastes are liquids with a pH of less than 2 (acidic) or greater than 12.5 (caustic). Examples of common corrosive wastes include:

- Mineral acids (hydrochloric or phosphoric acid)
- Nitric acid, chromic acid, chromerge
- Sodium or potassium hydroxide

5.5.1.3 Reactive Waste

Reactive wastes include water-reactive and air reactive materials. Cyanide and sulfide bearing wastes are also considered reactive due to toxic gas release when exposed to corrosives. Common lab reactive waste includes:

- Sodium metal, magnesium flake
- Sodium or potassium cyanide
- Hydrogen sulfide

5.5.1.4 Toxic Waste

Toxic wastes are a list of forty distinct chemicals or compounds that have been designated by the EPA to cause damage to human health. A waste will be considered toxic if the concentration of the toxin in the waste is above the cited concentration.

5.5.1.5 Listed Waste

Listed wastes are unused chemical products (usually in the original container) that are either out of date or will no longer be used in the laboratory. The EPA has developed two sets of listed wastes:

- U-Listed – a list of over 480 chemicals or chemical compounds.
- P-List – a list of 240 chemicals or chemical compounds considered acutely toxic by EPA.

5.5.2 Collection and Labeling of Hazardous Waste

Hazardous waste must be collected and labeled appropriately in the laboratory. Hazardous waste may never be disposed of in the sink or in the regular trash. Incompatible materials may never be collected for disposal in the same container.

5.5.2.1 Hazardous Waste Collection Containers

Hazardous waste is to be collected in a container that is compatible with the waste. Call EHS for assistance with collection of hazardous materials for disposal.

Do not collect corrosive materials in metal containers, as the metal will corrode, releasing the contents. Laboratories should have prepared containers for waste collection prior to beginning experiments. Compatible material of the same hazard may be collected in a single container. As an example, a laboratory may use a 5-gallon carboy to collect all compatible flammable solvents and alcohols. Another container may be used to collect compatible acidic waste, while a third may be used to collect compatible caustic wastes.

If a container that will be used to collect waste previously held a chemical product, be sure the original chemical from the container is compatible with the waste that will be added. For example, an empty container of acetone may be used to collect flammable solvents and alcohols, however, a container that previously held hydrochloric acid must not be used to hold cyanide waste.
Regulations require that all waste containers must be closed completely unless waste is being added. This means bottle caps must be screwed on, and lidded funnels must be closed and latched.

5.5.2.2 Labeling Hazardous Waste Containers

Hazardous waste collection containers must be labeled with either the full chemical name of the waste (abbreviations are not acceptable on hazardous waste labels), or a description of the type of waste in the container (Waste Flammable Solvent, Waste Acid Solution). See examples below.

Example 1.

FLAMMABLE

ORGANIC SOLVENT WASTE

Example 2.

HAZARDOUS WASTE
SODIUM CYANIDE

Prior to labeling a hazardous waste container, be sure that all previous labels or markings are defaced or removed. This will prevent confusion as to the contents of the container.

5.5.2.3 Disposal of Hazardous Waste

EHS handles removal and disposal of all hazardous waste on campus. Laboratories with higher generation rates of waste will have waste removed on a weekly basis. Labs with lower waste generation rates should call or e-mail the EHS office for waste removal. Be sure to provide the following information:

- Your name, phone number and e-mail address
- Department, building and lab number
- Type and quantity of waste, and the location of the waste in the lab.

EHS will then schedule pick up for the next weekly waste collection day.

5.5.3 Broken Glass and Sharps

Broken glass and sharps must both be handled with extreme care in the laboratory to prevent accidental puncture wounds.

5.5.3.1 Broken Glass

Broken glass and empty glass bottles are to be collected in designated glass waste boxes in each laboratory. The box may be purchased prefabricated, although standard heavy duty cardboard boxes

may be used as long as all original markings on the box are defaced or removed. The box must be marked with the words ``**BROKEN GLASS”** on at least opposite sides. The box must be lined with a heavy mil (9 mil minimum) plastic bag.
Do not place bottles or glass in the box that is clearly heavily contaminated with chemical residue or potentially biohazardous substances. Free liquids or sharps (needles, razors) may not be placed in the box.
Do not overfill the box. Do not use a large box that will become overly heavy or awkward to lift. It is the responsibility of lab personnel to close and tape shut the broken glass box when it is full. Be sure no glass or sharp edges are protruding from the box. Once taped shut, place the box in the hall outside the lab door for removal by Custodial Services. It is not the responsibility of Custodial Services to tape boxes closed or to remove boxes from laboratories.

5.5.3.2 Sharps Disposal

Sharps include needles, razors, scalpels, and any other laboratory instruments that may cause punctures or cuts to human skin. The following rules must be followed when disposing of sharps.

- Contaminated needles and other contaminated sharps shall not be bent, recapped, or removed from syringes.
- Immediately or as soon as possible after use, contaminated sharps shall be placed in appropriate Sharps containers
- Sharps must be disposed of in a container that is rigid, leak-proof when in an upright position and puncture resistant.
- The container must be labeled with the biohazard symbol and the words “Sharps” and "Biohazard."
- Do not overfill the sharps container. Once full, close the container lid and replace with an empty sharps container.
- Properly dispose of full sharps containers.

5.6 Working with Biohazards

Some toxic chemical compounds are not synthesized, but purified from biological sources. See the WFU Biosafety Plan for additional information.

6. Activities Requiring Prior Approval

Due to the inherent nature of their hazard, some activities will require prior approval from the PI before lab personnel begin the activity.
Before beginning any work in the laboratory, personnel must be trained in the following:

- General Lab Safety
- CHP and the Laboratory Standard
- Emergency Procedures
- Read and understand the SOPs developed for the work in which they will be engaging.

The PI or designee will ensure that these steps have been completed and that the individual understands the information, prior to beginning laboratory work.

In addition, PI approval is necessary before any individual begins work with any of the following:

- Particularly Hazardous Substances – including carcinogens, reproductive toxins, and acutely toxic material.
- Radiological Material
- Select Agents
- Controlled Substances
- Lasers
- Pyrophoric or Explosive Material (Refer to Section IX. Emergencies, Subsection B(6) & (7))
- Compressed Gas Cylinders (Refer to Section IX. Emergencies, Subsection B(9))

These materials require review of the SOP, and confirmation from the PI that the individual is competent to work with the material, is aware of the hazards and methods of protection, and understands emergency procedures should an accident or exposure occur with the material.

6.1 Particularly Hazardous Substances

OSHA requires provisions be made for lab personnel protection when working with Particularly Hazardous Substances. These materials include carcinogens, reproductive toxins, and acutely toxic substances.
The provisions for working with these substances may include, but is not limited to:

- Establishing a designated area for work
- Use of containment devices such as a fume hood or glove box
- Procedures for safe removal of waste contaminated with the substance
- Decontamination procedures

These provisions are to be listed in the SOP for the substance, and are to be reviewed by lab personnel prior to working with the substance.

6.1.1 Carcinogens

Carcinogens are substances capable of causing cancer. Carcinogens cause damage after repeated exposure or after exposure for long-durations. Effects of carcinogens are typically not evident until after a long latency period. Following guidelines set by OSHA, the National Toxicology Program (NTP) and the International Agency for Research on Cancer (IARC), Wake Forest University considers any of the following materials to be carcinogens:

6.1.1.1 OSHA Subpart Z Regulated Carcinogens

Below is the current list of OSHA regulated carcinogens found in 29 CFR 1910 Subpart Z.

- 1,2-dibromo-3-chloropropane
- 1,3-Butadiene
- 2-Acetylaminofluorene
- 3,3'-Dichlorobenzidine (and its salts)
- 4-Aminodiphenyl
- 4-Dimethylaminoazobenzene
- 4-Nitrobiphenyl
- Acrylonitrile
- alpha-Naphthylamine
- asbestos
- Benzene

- Benzidine
- beta-Naphthylamine
- beta-Propiolactone
- bis-Chloromethyl ether
- Cadmium
- Coke oven emissions
- Ethylene oxide
- Ethyleneimine
- Formaldehyde
- Inorganic arsenic
- Methyl chloromethyl ether
- Methylene Chloride
- Methylenedianiline
- N-Nitrosodimethylamine
- Vinyl chloride

6.1.1.2 NTP and IARC carcinogens

NTP carcinogens are categorized into several classes. For this CHP, those listed as “known to be human carcinogens” and those listed as “reasonably anticipated to be human carcinogens” in the NTP’s *Report on Carcinogens* (RoC) are applicable to this section.

6.1.2 Reproductive toxins

Reproductive toxins are defined by OSHA as “chemicals that affect the reproductive capabilities including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring.” These chemicals are classified by OSHA under 29 CFR 1910.1200.

6.1.3 Acutely Toxic Substances

The preamble to OSHA Lab Standard states, substances with high acute toxicity “may be fatal or cause damage to target organs as a result of a single exposure or exposure of short duration”. Examples given are substances such as hydrogen cyanide, hydrogen sulfide, and nitrogen dioxide. Follow the GHS standard for acute toxicity, where compounds falling under Category 1 or 2 meet the criteria for this section.

Acute Toxicity

Acute toxicity	Cat. 1	Cat. 2	Cat. 3	Cat. 4	Category 5
Oral (mg/kg)	≤ 5	> 5 ≤ 50	> 50 ≤ 300	> 300 ≤ 2000	Criteria: ▪ Anticipated oral LD50 between 2000 and 5000 mg/kg; ▪ Indication of significant effect in humans;* ▪ Any mortality at class 4;* ▪ Significant clinical signs at class 4;* ▪ Indications from other studies.* *If assignment to more hazardous class is not warranted.
Dermal (mg/kg)	≤ 50	> 50 ≤ 200	> 200 ≤ 1000	> 1000 ≤ 2000	
Gases (ppm)	≤ 100	> 100 ≤ 500	> 500 ≤ 2500	> 2500 ≤ 5000	
Vapors (mg/l)	≤ 0.5	> 0.5 ≤ 2.0	> 2.0 ≤ 10	> 10 ≤ 20	
Dust & mists (mg/l)	≤ 0.05	> 0.05 ≤ 0.5	> 0.5 ≤ 1.0	> 1.0 ≤ 5	

Other sources of information include the SDS, the Registry of Toxic Effects of Chemical Substances (RTECS), and the Poison Control Center.

6.2 Select Agents and Toxins

Select Agents and Toxins are biological agents or substances that have the potential to pose a severe threat to human, animal, and / or plant health, or to animal and plant products. These agents are regulated through a joint federal program administered by CDC and the Animal and Plant Health Inspection Services/Agricultural Select Agent Program (APHIS).

Possession, transfer and use of select agents and toxins is regulated under 7 CFR 331, 9 CFR 121 and 42 CFR 73. An Application for Registration must be completed through the National Select Agent Registry prior to possession, transfer or use. This must be reviewed by EHS prior to submission. Due to potential hazards of these substances, a full review of the laboratory requesting the application, personnel involved, and all procedures must take place prior to submission.

6.3 Controlled Substances

The Office of Diversion Control of the Drug Enforcement Agency (DEA) regulates the possession and use of controlled substances. Controlled substances are drugs or other substances, or immediate precursor, included in schedule I, II, III, IV, or V of 21 CFR 1308. The term does not include alcoholic beverages or tobacco.
The PI must register with the DEA and obtain a DEA license prior to accepting possession of a controlled substance. Detailed storage and use records must be maintained, and special controlled substance disposal procedures must be followed. The summary of information and requirements is detailed in *Guidelines: Use of Controlled Substances in Research* available on the EHS website.

7. Medical Assistance, Consultations and Evaluations

7.1 First Aid

First aid kits are available in each department. Contact the PI or Lab Manager for the location. Be sure you alert the PI if the first aid kit needs to be restocked.
The first aid kit is for minor, non-life threatening injuries. However, it is still required that a First Report of Injury or Injury form be completed by the injured person and PI, and submitted to Human Resources.

7.2 Injuries Requiring Medical Attention

For any life-threatening injury, immediately call 911, or x5911 on a campus phone. Describe the victim's injury, your location (building, floor, room), and a phone number the 911 operator can call if the line becomes disconnected. Never leave the victim alone. Direct another individual to call 911 if you are not near a phone, and have an individual meet arriving medical personnel and bring them to the victim.
Be sure to protect yourself before administering any assistance. Don gloves, eye protection, and lab coat, if necessary, to avoid potential chemical contact and to avoid blood contact.

For non-life threatening injuries that require medical attention, undergraduate and graduate students should proceed to the Student Health Center. Be sure to inform the PI that an injury has occurred, and at the earliest opportunity complete the First Report of Student Injury form.
Employees injured in the lab should alert their supervisor and proceed to a Wake Forest University occupational health medical provider. Locations can be found on the Human Resources website.

7.3 Monitoring and Evaluations

Monitoring of laboratory conditions will occur whenever there is the likelihood that published action levels or PEL may be exceeding in a laboratory. EHS will oversee monitoring events, and provide guidance and instructions to lab personnel. Results of monitoring are made available to individuals monitored and the PI and Department Chair within 15 days of receipt of the analytical results.
Medical consultation and examinations will be provided to employees when:

- An employee develops signs or symptoms associated with exposure to a hazardous chemical in the lab.
- If exposure monitoring reveals an exposure level routinely above OSHA or NIOSH limits.
- A spill or release of a hazardous chemical(s) likely results in an exposure to personnel in the lab.

EHS, in conjunction with Human Resources, will provide the employee the name and address of a physician's office or care center where the examination can take place. Information to be provided to the physician will include:

- "The identity of the hazardous chemical(s) to which the employee may have been exposed;
- A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
- A description of the signs and symptoms of exposure that the employee is experiencing, if any (29 CFR 1910.1450 (g))."

The physician's written opinion will include:

- "Any recommendation for further medical follow-up;
- The results of the medical examination and any associated tests;
- Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace; and
- A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment (29 CFR 1910.1450 (g))."

8. Information and Training

General laboratory training is required prior to working in the lab. This applies to students (undergraduate and graduate), staff, and faculty. The University hosts an online training system (HSI Vivid) that will be used to provide basic instruction on working safely in laboratory environments.

8.1 Laboratory Research Checklist

Individuals working in research laboratories are required to complete the Research Laboratory Training Checklist prior to beginning work in the lab. PI’s are required to review the information on the checklist with each individual under their supervision.

8.2 Specialized Training

Certain operations performed in laboratories will require additional information and training. Most of the additional requirements can be found at the Wake Forest University Environmental Health and Safety web-site.

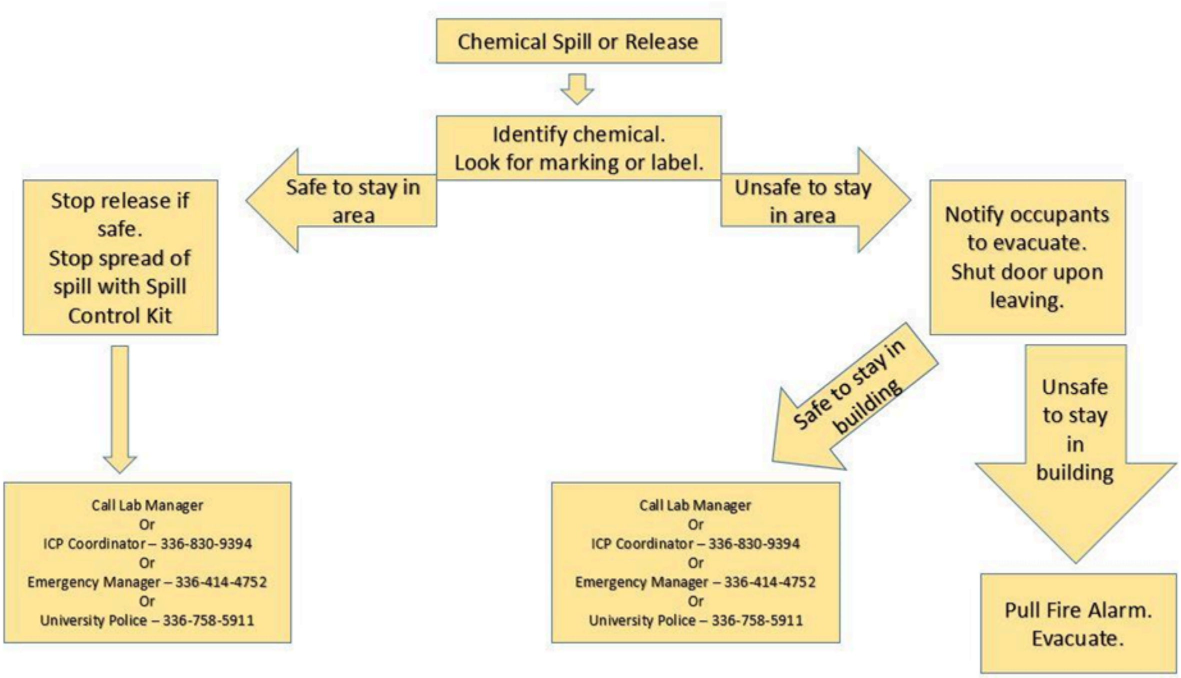
9. Emergencies

Medical emergencies were discussed previously in Section VII. Spills or releases of hazardous materials, fires, and weather related events also constitute emergencies that will require proper action to minimize potential consequences.

9.1 Spills and Releases

Spills and releases of hazardous materials have the potential to cause physical damage to persons and property as well as toxicological exposure. Prompt response to spills is essential in minimizing hazards.

Follow the flow chart to determine the course of action if there is a chemical spill or release.



9.1.1 Flammable Liquid Spill

Flammable liquids with flashpoints less than 140F pose a fire hazard when spilled. Open flames in the area should immediately be extinguished and any operations that may cause sparking must be stopped during clean up.

9.1.2 Corrosive Liquid Spill

Corrosive spills can cause damage to living tissue on exposure to skin, and may burn lungs and trachea upon inhalation of vapors. Set fume hoods to Emergency Exhaust to assist in removing vapors.

9.1.3 Toxic Chemical Spill

Toxic chemicals can cause both acute and chronic health issues and in some cases may lead to permanent injury or death. Any spilled substance that is a poison by inhalation hazard requires immediate evacuation of the lab. Only trained personnel from EHS, WSFD, or approved contractors may clean up spills of poison by inhalation. Other toxins may only be cleaned by individuals trained to do so, and who are wearing appropriate PPE to prevent exposure.

9.1.4 Gas Cylinder

Leaks from compressed gas cylinders can be life threatening by asphyxiation, poisoning, and / or explosion. Immediately evacuate the area and notify the Lab Manager or Security.

9.1.5 Cleaning a Minor Spill

Minor spills in the laboratory can be cleaned using chemical spill kits available in each department. Ask the Lab Manager for the location of the nearest spill kit to the lab. A minor spill is one that would require no more than one person and no more effort than general housecleaning to clean. Refer to the SDS for proper spill clean-up procedure. Report minor spills to the Lab Manager so spill kit materials used during clean-up can be replenished if necessary. Collected spill material must be containerized and labeled as waste, and include the proper chemical name. Contact EHS to have the spill container removed from the lab.

9.2 Fire

Uncontrolled fire in the laboratory is life threatening due to the storage of potential sources of fuel and oxygen located in many labs that may add to a conflagration. Use a fire extinguisher only if you know the type of fire that has occurred (chemical, electrical, paper, etc.), you have the correct extinguisher for the fire, and the fire is not an immediate threat to life or health.

9.2.1 Types of Fire

There are five classes of fire. These are categorized based on the material (fuel) that is burning. Most laboratories are susceptible to at least three, if not four of these categories. The information below is from the Fire Equipment Manufacturers' Association (FEMA, not to be confused with the Federal Emergency Management Agency, having the same acronym).

9.2.1.1 Class A fire

Class A fires are fires in ordinary combustibles such as wood, paper, cloth, trash, and plastics.

9.2.1.2 Class B Fires

Class B fires are fires in flammable liquids such as gasoline, petroleum oil and paint. Class B fires also include flammable gases such as propane and butane. Class B fires do not include fires involving cooking oils and grease.

9.2.1.3 *Class C Fires*

Class C fires are fires involving energized electrical equipment such as motors, transformers, and appliances. Remove the power and the Class C fire becomes one of the other classes of fire.

9.2.1.4 *Class D Fires*

Class D fires are fires in combustible metals such as potassium, sodium, aluminum, and magnesium.

9.2.1.5 *Class K Fires*

Class K fires are fires in cooking oils and greases such as animals fats and vegetable fats.

Laboratories on campus are equipped with at least one ABC fire extinguisher. This refers to the three classes of fire for which the extinguisher is suitable. Labs that work often with, or with large quantities of, combustible metals should have a Class D extinguisher available. Ask the PI or Lab Manager for the location of the Class D extinguishers in the building.

9.2.2 Fire Extinguisher Use

To operate a fire extinguisher, remember the word PASS:

- **P**ull the pin. Remove the fire extinguisher pin by pulling firmly.
- **A**im low. Point the extinguisher nozzle at the base of the fire.
- **S**queeze. Slowly and evenly squeeze the handle.
- **S**weep. Sweep the nozzle back and forth at the base of the fire.

Before using a fire extinguisher, notify all lab occupants to evacuate. Pull the fire alarm. The building must be evacuated in the event it becomes too large to be extinguished with the fire extinguisher. Always keep your back to a clear exit when using the fire extinguisher. This will ensure an unimpeded escape route should the fire continue to grow. If you feel that your life is in danger, do not use the fire extinguisher. Instead, pull the fire alarm and evacuate the building.

9.2.3 Fire Prevention Guidelines

Fire prevention is accomplished by reducing its potential through education, the observation of safe work practices, housekeeping and inspections. The fire prevention guidelines include:

- Observe proper housekeeping by keeping work areas uncluttered and clean
- Keep chemical storage areas neat and clean
- Be cognizant of the location and use of all emergency equipment (such as fire extinguishers, eye washes, and safety showers) in the laboratory
- Always plan laboratory work before executing it. You should understand the hazards associated with the chemicals involved before you start the experiment. The majority of lab fires have resulted from mental or procedural errors or carelessness.
- Minimize materials and avoid accumulating excessive paper products and corrugated materials. This minimizes fire risk and reduces costs and waste.
- Do not store combustible items such as paper and cardboard against electrical panels, in telephone closets, stairwells, and corridors
- Do not store large quantities of flammable, combustible liquids and gases outside a flammable storage cabinet
- Avoid using extension cords and maintain electrical equipment in good working order. Periodically check for potential electrical hazards such as frayed cords, broken plugs and overloaded electrical outlets.
- Do not block exit doors or emergency equipment.
- Observe restrictions on equipment (keep solvents only in an explosion-proof refrigerator)
- Keep hood sash closed or as low as possible to save energy and maximize safety to laboratory personnel.
- Keep barriers in place (shields, hood doors, lab doors)

9.2.4 Bunsen Burner Safety Guidelines

For the safety and convenience of everyone working in a laboratory, the following guidelines must be observed. In case of a fire, activate the nearest fire alarm pull station, notify all lab personnel, and evacuate the building. Contact the biosafety officer if you would like to use any type of open flame in a biosafety cabinet. EHS recommends the use of natural rubber latex tubing and a Bunsen burner with no-tip safety base and flame stabilizer. Bunsen burners may not be used in Biosafety Cabinets.

- Remove all papers, notebooks, combustible materials and excess chemicals from the area. Be cognizant of what is stored above your immediate work area.
- Tie-back any long hair and avoid wearing loose clothing. Make use of appropriate PPE!
- Inspect hose for cracks, holes, pinch points or any defect and ensure that the hose fits securely on the gas valve and the burner
- Replace or trim all hoses found to have a defect before using
- Utilize a sparker/lighter with extended nozzle to ignite the burner. Never use a match to ignite a burner.
- Adjust the flame to regulate air flow and produce an appropriate flame for the experiment.
- Do not leave open flames unattended and never leave the laboratory while the burner is on
- Shut off gas when its use is complete.

- Allow the burner to cool before handling.

9.2.5 Flammable Liquid Cabinets

- Flammable liquids in quantities **exceeding a total of 10 gallons** in a laboratory must be stored in flammable liquid storage cabinets. Flammable storage cabinets shall be designed to meet NFPA and North Carolina Fire Code. Class 1 Flammable liquids cannot be stored below grade as per the Fire Code.
- No more than 60 gallons of a Class I flammable liquids (flash point below 100°F) or class II combustible liquids (flash point between 100°F to 140°F) may be stored in a flammable-liquids storage cabinet.
- No more than 120 gallons of a class III combustible liquid (flash point between 140°F and 200°F) may be stored in a flammable -liquids storage cabinet
- Approved flammable-liquids cabinets should be marked in conspicuous letters "**Flammable-Keep Fire Away."**
- All flammable liquid storage cabinets must be grounded. The grounding cable must be connected to a building structural member or an electrical building ground. Due to increased use of plastic piping, (which breaks the ground) water pipes must not be used for grounding.

9.2.6 Pyrophoric substances

Pyrophoric materials are substances that will ignite spontaneously in air, while explosives are reactive materials that detonate with a corresponding shock wave. Working with either material requires great care to prevent accidental ignition or detonation.

9.2.6.1 Pyrophoric Reagents

Pyrophoric materials are used routinely in some laboratories, especially within the Chemistry Department. Common pyrophoric compounds include:

- Organolithium compounds (t-Butyllithium)
- Organozinc compounds (Diethylzinc)
- Organomagnesiums (Grignard reagent)
- Aluminum alkyls
- Metallic hydrides (sodium or potassium hydride)
- Metal powders and fines (Aluminum, Lithium, Sodium, Magnesium)

Pyrophoric reagents are typically stored in highly flammable solvent such as Ethyl ether, Hexanes, or Tetrahydrofuran (THF). This adds to the potential hazard of the pyrophoric material in that it is mixed with a flammable liquid.

9.2.6.2 Pyrophoric Engineering Controls

Prior to working with pyrophorics, the Aldrich Technical Bulletins AL-134, Handling Air-Sensitive Reagents and AL-164 Handling Pyrophoric Reagents must be read and all safety precautions followed.

- Pyrophoric liquids are to be stored in PTFE septa bottles to prevent exposure to air.
- Pyrophoric liquids may only be transferred using a syringe with needle locking mechanisms to prevent inadvertent release.
- Mineral oil bubblers must be used to release pressure from reaction vessels. Balloons are unacceptable.
- Handling of pyrophoric liquids must take place in an operational fume hood with the sash lowered as much as practicable. Pyrophoric solids may only be handled in an inert atmosphere glove box.

9.2.6.3 Pyrophoric Administrative Controls

Lab personnel must be trained by the PI or designee prior to using pyrophoric materials, and show competency before working individually. The training will include understanding of the hazards and emergency procedures.
Personnel using pyrophorics must wear a fire resistant lab coat (Nomex coated). Kevlar or leather gloves should be worn beneath nitrile gloves to provide greater fire protection.

9.2.7 Explosive Substances

Explosive reactions cause immediate release of pressure, gas, and shock. Aside from these hazards, flying debris as a by-product of the explosion can cause injury or death.

9.2.7.1 Explosives Engineering Controls

- A rated blast shield must be used whenever working with explosives.
- All work with explosives must be performed in the fume hood. Any unnecessary material in the hood must be removed prior to work with explosives.
- Do not rely on the fume hood sash alone as protection. The sash will not protect from flying debris.

9.2.7.2 Explosives Administrative Controls

As with pyrophorics, lab personnel must be trained by the PI or designee prior to using explosive materials, and show competency before working individually. The training will include understanding of the hazards and emergency procedures. All other personnel in the area are to be alerted that explosives will be used prior to beginning work.

9.2.8 Refrigeration/Freezing of Flammable liquids

Fires and explosions can and do occur in either general-purpose laboratory or ordinary domestic refrigerators or freezers when these types of appliances are used to store volatile or flammable materials.

There are basically three different types of refrigerators/freezers:

9.2.8.1 Household (Domestic) Refrigerators/freezers

Refrigerators and freezers that can be used in laboratories for storage of aqueous solutions and nonflammable chemicals and samples. A household refrigerator **does not** provide safe storage for flammable solvents and has very low flashpoints and flammable limits (lowest vapor concentration that can be ignited with a spark). In addition, household refrigerators commonly contain exposed sources of ignition such as thermostat, lights, defrost heater, defrost control switch, the compressor unit, and the fan that can ignite flammable vapors released from poorly sealed or broken containers and caused harmful lab explosions.

9.2.8.2 Laboratory-Safe (Flammable Safe) Refrigerators/freezers

Laboratory-Safe Refrigerators/freezers which are used for storage of flammable or explosive materials. This type of refrigerator is designed with a cooling technology which has no internal switching devices that can arc or spark as a source of ignition. These refrigerators also incorporate design features like thresholds, self-closing doors, magnetic door gaskets, compressors and circuits located at the top of the unit to reduce the potential for ignition of floor-level flammable vapors. Special inner shell materials control or limit damage should an exothermic reaction occur within the storage compartment. The electrical components in this type of refrigerator are outside the refrigerator, and the compressor is sealed or located at the top of the unit.

9.2.8.3 Explosion- Proof Refrigerators/freezers

Explosion-proof refrigerators are designed to protect against ignition of flammable vapors both inside the storage compartment and outside the refrigerator. It is operational in areas where the air outside the refrigerator might be explosive. This often includes liquids gases, or solids with flashpoints of less than 100°F. These refrigerators feature enclosed motors to eliminate sparking and bear a FM® (Factory Mutual) or UL ® (Underwriters Laboratory) explosion-proof label. Such refrigerators must meet the requirements for Class 1, Division 1 Electrical Safety Code (NFPA45 and 70) and require direct wiring to the power source via a metal conduit. These refrigerators must be used in locations such as solvent dispensing rooms, where a flammable atmosphere may develop at some time in the room.
To prevent refrigerator and freezer explosions,

- All materials with a flashpoint below 1000°F (38°C) may ONLY be stored in a UL approved flammable materials storage refrigerator or freezer. These units do not have any internal ignition sources.
- All ordinary domestic refrigerators and freezers should be labeled with the phrase "No materials with a flashpoint below 100°F (38°C) may be stored in this refrigerator/freezer" or "Not for flammable storage."

9.2.9 Compressed Gas Cylinders

Compressed gas cylinders are hazardous not only from release of contents (if a toxic or physical hazard), but also from the fact the vessels are under pressure. Instantaneous loss of pressure will propel the cylinder with enough force that it will be capable of penetrating concrete block walls.
By Fire Code, cylinders must always be secured either by chain or strap to a wall or laboratory bench.

The following rules for compressed gas cylinders have been developed for the entire University:

- Identifying labels must be kept in place on cylinders.
- Keep lecture bottles in ventilated lower hood cabinets when not in use.
- Store flammable gases (Hydrogen gas) away from oxidizers (Oxygen gas) and corrosives.
- Store gas cylinders in a ventilated and well-lit area away from combustible materials, Separate specialty gases by type and store in assigned locations that can be readily identified.
- Do not use inappropriate hose material as dispensing tubes from gas cylinder regulators. Corrosive gases may destroy rubber or latex tubing. Tygon tubing should perhaps be used instead, or copper or stainless steel.
- When cylinders are no longer in use, take off their regulators, cap them with valve caps, and return them to storage. Do not allow unused cylinders to accumulate in your laboratory.
- Corroded cylinder valve stems, gas line fittings, or regulators are a source of danger and should be exchanged for better quality equipment.
- Handle gas cylinders with extreme care. They are, of course, under a great deal of pressure and would transform themselves into fairly powerful missiles if the valve stem on top were to be sheared off. This could conceivably happen if they were dropped, especially if the valve stem falls against something on the way down. This will only be prevented if you endeavor to keep the valve cap on when moving the cylinder.

- Take the regulator off the cylinder before moving. Move the cylinder on a two-wheeled chain cylinder dolly or similar device made specifically for cylinders. Chain the cylinder and push the cart slowly. Never move a cylinder without a threaded valve cap cover attached.
- Never leave cylinders unstrapped in the lab. Secure them against a wall or a lab bench.
- Keep track of where you store cylinder caps for cylinders being in use.
- Do not grease or oil the regulator thread of a cylinder valve. Oil on a gas cylinder thread will soon be under very high pressure. If the gas reacts at all with organic material, this could lead to an explosion. This is especially true for Oxygen gas cylinders and other oxidizing gas cylinders, valves, and systems. Never allow oil, greases and other readily combustible substances to come in contact with oxygen cylinders, valves, regulators, and fittings. Teflon tape can be used on the outlet side of the regulator, but not on the primary fitting connection between the regulator and the cylinder.
- Never use a cylinder without an attached regulator.
- Add flashback arrestors to oxygen and hydrogen cylinders when used for torches for glass blowing or glass working. Flashback occurs when flames actually traverse through the gas line back to the cylinder outlet.
- Do not completely empty a cylinder before returning it to the loading dock area. Slight positive pressure (between 5 and 15 psi) will keep atmospheric oxygen from contaminating the cylinder contents, so that the cylinder can be safely refilled by the gas cylinder supplier.
- Do not over-tighten a hand-valve on a gas cylinder. If hand tightening will not completely close the valve, call the gas cylinder company for removal.
- Do not allow areas where cylinders are stored to exceed 52oC (125oF)

9.2.10 Fire Extinguisher Training

EHS provides training to employees and students upon request in fire safety techniques. Fire Extinguisher Training is offered by EHS to Faculty/staff and personnel working in the lab. The intent of the training is to educate university personnel on basic fire safety techniques and the proper procedure for using a portable fire extinguisher. The training course concludes with hands- on practice utilizing the training equipment.

9.3 Weather Related Emergencies

Due to the unpredictability of weather, weather related emergencies can develop slowly or very rapidly. It is important to always be prepared in the event of a sudden emergency to lessen potential hazards.

9.3.1 Tornadoes and Severe Thunderstorms

Both tornadoes and severe thunderstorms exhibit high velocity winds that are capable of throwing objects hundreds of yards, with the potential for broken windows, flying glass, and downed trees and power lines. Be alert to changing weather conditions, especially in spring and summer months, when tornadoes and severe thunderstorms are most prevalent.

If a tornado alert is issued for the campus, the University Wake Alert System will notify all faculty, staff and students. Immediately shut off any open flames and turn off all non-essential electrical items. Evacuate the lab into the hallway and close the lab door as you leave. If time permits, go to the lowest floor and innermost part of the building and wait for instructions.

9.3.2 Winter Weather

Winter weather ice or snow storms generally provide advanced warning prior to arrival. Winter storms have the ability to cause power outages and make roads impassable for periods of time. Prepare the laboratory prior to the arrival of a winter storm. The lab should be secured as if it were to be unoccupied for at least three to four days. This means that only absolutely essential items may be powered on, and must be able to operate safely without attention for at least three to four days. No experiments or operations should be left that will require attention by lab personnel, as travel may be impossible.

Appendix I: Standard Operating Procedures

Standard Operating Procedure (SOP) information sources include the following:

- Columbia University in the City of New York, Environmental Health and Safety, http://ehs.columbia.edu/
- Duke University and Duke Medicine Occupational & Environmental Safety Office, https://www.safety.duke.edu/
- National Research Council of the National Academies. (2011). *Prudent practices in the laboratory: Handling and management of chemical hazards*. (Updated ed.). Washington, DC: The National Academies Press.
- State University of New York at Stony Brook, Environmental Health and Safety, http://www.stonybrook.edu/ehs/
- Texas A&M University, Environmental Health and Safety, https://ehs.tamu.edu/
- The MSDS HyperGlossary, http://www.ilpi.com/msds/ref/index.html
- University of California, Berkeley Office of Environment, Health and Safety, http://ehs.berkeley.edu/
- Wake Forest School of Medicine, Environmental Health and Safety, https://school.wakehealth.edu/about-the-school/facilities-and-environment/environmental-health-and-safety
- Washington University of St. Louis, Environmental Health and Safety, http://ehs.wustl.edu/Pages/default.aspx

The following SOPs have been developed by the WFU Office of Environment, Health and Safety and are available on the Wake Forest University EHS website - https://ehs.wfu.edu/. Additional SOPs may be required for individual labs. It is the responsibility of the PI to determine the SOPs necessary and to develop those not listed. SOPs should be made available to lab personnel in the *Laboratory Protocols* folder of the **Laboratory Safety Notebook**.

- Benzene
- Blood and Bodily Fluids
- Carcinogens, Reproductive Toxins and Acutely Toxic Compounds
- Chloroform
- Compressed Gases and Cryogenic Liquids
- Corrosives
- Diethyl ether
- Distillation at Atmospheric Pressure
- Ethidium bromide
- Flammables
- Formaldehyde
- Human Gross Anatomy
- Hydrofluoric acid
- Liquid Nitrogen
- Nitric acid
- Osmium tetroxide
- Oxidizers
- Peroxide forming chemicals
- Phenol
- Pyrophorics
- Sodium azide

- Sodium hypochlorite (Bleach)
- Water Reactive

Appendix II: Common Laboratory Abbreviations

Abbreviation	Full Name
Ac	Acetyl
Ac2O	Acetic anhydride
AcO	Acetate
Bn	Benzyl
Boc	tert-Butoxycarbonyl
BSA	bovine serum albumin
Bu or n-Bu	n-Butyl
Bz	Benzoyl
Bzl	Benzyl
$Ca(OH)_2$	Calcium hydroxide
$CaCO_3$	Calcium carbonate
$CaSO_4$	Calcium sulfate
CH3COOH	Vinegar
CH4	methane
CMF-DPBS	calcium- and magnesium-free Dulbecco phosphate-buffered saline
CO	Carbon monoxide
CO2	Carbon dioxide
CSA	Camphorsulphonic acid
DABCO	1,4-Diazabicyclo[2.2.2]octane, Triethylendiamine
DCM	Dichloromethane
DMEM	Dulbecco modified Eagle medium
DMF	N,N-Dimethylformamide
DMP	Dess-Martin periodinane
DMS	Dimethylsulfide
DMSO	Dimethylsulfoxide
DPA	Diisopropylamine
DPBS	Dulbecco phosphate-buffered saline
DTT	dithiothreitol
EDTA	Ethylenediaminetetraacetic acid
EE	Ethoxyethyl
EOM	Ethoxymethyl
Et2O	Diethyl ether
EtBr	Ethidium bromide
EtOH	Ethanol
H2CO3	carbonic acid
H_2O2	Hydrogen peroxide
H2SO4	sulfuric acid
HBSS	Hanks balanced salt solution
HCl	hydrochloric acid
HClO4	perchloric acid
HCN	hydrocyanic acid
HNO3	nitric acid
Im	Imidazole
IPA	Isopropyl alcohol
IPTG	Isopropyl β-D-1-thiogalactopyranoside
KCl	Potassium chloride
KNO_3	Potassium nitrate

Abbreviation	Full Name
KOH	Potassium hydroxide
Me	Methyl
MEK	Methyl ethyl ketone
MIBK	Methyl isobutyl ketone
MOM	Methoxymethyl
MOPS	3-(N-morpholino)propanesulfonic acid
MS	Molecular sieves
MTBE	Methyl tert-butyl ether
N2	nitrogen gas
Na_2CO_3	Sodium carbonate
Na_2CO_4	Sodium percarbonate
$NaBO_3$	sodium perborate
NaCl	Sodium chloride
NaCl	Sodium chloride
NaOH	Sodium hydroxide
NH3	Ammonia
$(NH_4)_2SO_4$	Ammonium sulfate
O2	oxygen gas
PBS	Phosphate-buffered saline
PCR	Polymerase Chain Reaction
Ph	Phenyl
PMSF	phenylmethylsulfonyl fluoride
Pr	Propyl
Py	Pyridine
s-Bu or sBu	sec-Butyl
SDS	Sodium Dodecyl Sulfate
SDS-PAGE	Sodium Dodecylsulfate-Polyacrimide Gel Electrophoresis
SOB	Super Optimal Broth
SSC	saline-sodium citrate
TAE	Tris/acetate/EDTA
TBE	Tris-borate-EDTA
TBS	Tris buffered saline
t-Bu or tBu	tert-Butyl
TE	Tris-EDTA
TEA	Triethylamine
TEA	triethanolamine
TEMED	Tetramethylethylenediamine
TEN	Tris/EDTA/NaCl
TESH	Triethylsilane
Tf	Trifluoromethanesulfonyl
TFA	Trifluoroacetic acid
TFAA	Trifluoroacetic anhydride
Thexyl	2,3-dimethyl-2-butyl
THF	Tetrahydrofuran
TMEDA	N,N,N',N'-Tetramethylethylendiamine
TMS	Tetramethylsilane
Tol	p-Toluyl
TTBS	Tween 20/TBS

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