

Safety in the Chemical Laboratory

*A Vanderbilt Safety
Reference Manual*



**Vanderbilt Environmental Health &
Safety**

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Hazard Communication, The Lab Standard & The Chemical Hygiene Plan

The *Hazard Communication Standard*, also known as the *Right to Know Law* is mandated by the Occupational Safety & Health Administration (OSHA) in 29 CFR 1910.1200 and by the Tennessee Division of Occupational Safety & Health (TOSHA) in 0800-1-9. This standard requires that all employees (1) receive initial safety training about all hazardous chemicals at work and additional training whenever new hazardous chemicals are introduced, (2) have immediate access to and know how to use Material Safety Data Sheets (MSDS) and (3) are taught to label all containers of chemicals. The Hazard Communication mandated by TOSHA differs from OSHA in that TOSHA also requires annual retraining on hazardous chemicals.

Because of the special safety concerns that arise in a laboratory setting, OSHA developed the *Lab Standard* (29 CFR 1910.1450). The *Lab Standard* supplements the requirements of the Hazard Communication Standard by instituting these additional requirements:

- Each lab must have a written *Chemical Hygiene Plan*.
- The employer must maintain employee chemical exposures below the legal limits.
- Respiratory protection must be provided to maintain chemical exposure below the legal limits.
- The employer must provide free medical consultations and/or examinations if there is a suspected exposure.
- The employer must maintain records for chemical monitoring results, employee medical evaluations, and employee training.

The *Chemical Hygiene Plan* that is required by the *Lab Standard* must be specific for each lab and must provide a detailed chemical hygiene plan that outlines policies & procedures used to protect the laboratory workers. Material Safety Data Sheets must be immediately available in all laboratories.

Hazardous Chemicals

Chemicals may be classified as hazardous for several reasons. A chemical may cause injury or damage because of its toxic properties or because of some physical property. For instance, flammable chemicals are hazardous because they will catch fire and burn more readily than other chemicals and a chemical that is a poison causes an adverse health effect on some organ or organ system.

Chemicals That Can Cause Injury

Explosive Chemicals

Some chemicals are explosive and peroxide-forming chemicals can become explosive over time. The first time a container of a peroxide-forming chemical is opened, it must be labeled with the date. These chemicals should be turned over as hazardous waste to VEHS no later than six months from the date they have been opened. If you find a bottle of a peroxide forming chemical and you are not sure how old it is, DO NOT move it if there are white crystals present around on the container. Common examples of some peroxide forming chemicals include ethers, tetrahydrofuran, dioxane & dry picric acid. However, many other chemicals can also form peroxides.

Flammable Chemicals

Flammable chemicals will readily catch fire and burn in air. The most common flammable chemicals found in the laboratory are organic solvents. These chemicals must be stored in a flammable storage cabinet.

Corrosive Chemicals

Corrosive chemicals destroy exposed tissue through chemical action. The most common corrosive chemicals are acids (pH<7) and bases (pH>7). Acids and bases must be stored separately in cabinets that will not be corroded. Hydrofluoric acid is an especially hazardous acid, because it will not only corrode living tissue, it will also damage bone. Individuals who work with hydrofluoric acid must have the antidote, calcium gluconate, immediately available in case of an accident.

Cryogenic Liquids

Cryogenic liquids kill skin through flash freezing – frostbite. Since most cryogenic liquids also displace oxygen as they evaporate, they are hazardous in poorly ventilated areas.

Chemicals That Can Cause Adverse Health Effects

Acute health effects occur immediately after exposure to a toxic chemical. An example of an acute health effect would be passing out after inhalation of a toxin. Chronic health effects may not be evident until days, months, or even years after the exposure and may result from either one exposure or several exposures over a period of time. Emphysema and cancer are two examples of chronic health effects.

Highly/Acutely Toxic Chemicals

Highly or acutely toxic chemicals include any chemical that falls within any of the following OSHA defined categories:

- A chemical with a median lethal dose (LD50) of 50 mg or less per kg of body weight when administered orally to certain test populations.
- A chemical with an LD50 of 200 mg less per kg of body weight when administered by continuous contact for 24 hours to certain test populations.
- A chemical with a median lethal concentration (LC50) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable

Toxins & Select Agent Toxins

Toxins are chemicals created by plants, animals or microorganisms that are poisonous to humans. Certain toxins have been listed as *Select Agent Toxins* by the Centers for Disease Control (CDC). Vanderbilt is required to register these toxins with the CDC and must follow strict procedures for receipt, use, security and disposal. If you plan to use a *Select Agent Toxin*, contact the Biosafety Program Manager in the VEHS department. Following is a list of the *Select Agent Toxins*:



- | | |
|--|-------------------------------|
| ○ Abrin | ○ Shigatoxin |
| ○ Aflatoxins | ○ Staphylococcal enterotoxins |
| ○ Botulinum toxins | ○ Tetrodotoxin |
| ○ <i>Clostridium perfringens</i> epsilon toxin | ○ T-2 toxin |
| ○ Conotoxins | ○ Ricin |
| ○ Diacetoxyscirpenol | ○ Saxitoxin |

Carcinogens

A carcinogen is a substance capable of causing cancer. There are three sources that provide lists of carcinogens:

- These carcinogens have been specifically listed by OSHA in Subpart Z of the OSHA standards:

Chemical	Chemical Abstracts (CAS) Number
4-Nitrobiphenyl	92933
alpha-Naphthylamine	134-32-7
methyl chloromethyl ether	107302
3,3'-Dichlorobenzidine (and its salts)	91-94-1
bis-Chloromethyl ether	542881
beta-Naphthylamine	91-59-8
Benzidine	92--87-5
4-Aminodiphenyl	92-67-1
Ethyleneimine	151564
beta-Propiolactone	57-57-8
2-Acetylaminofluorene	53963
4-Dimethylaminoazo-benzene	60117
N-Nitrosodimethylamine	62-75-9
Vinyl Chloride	75-01-4
Inorganic Arsenic	7440-38-2
Cadmium	7440-43-9
Benzene	71-43-2
1,2-Dibromo-3-chloropropane	96-12-8
Acrylonitrile	107-13-1
Ethylene oxide	75-21-8
Formaldehyde	50-00-0
Methylenedianiline	101-77-9
1,3-Butadiene	106-99-0
Methylene chloride	75-09-2

- The *National Toxicology Program (NTP)* lists chemicals under the category "known to be carcinogens" in the *Annual Report of Carcinogens* (<http://ntp-server.niehs.nih.gov/>).
- The *International Agency for Research on Cancer (IARC)* has divided chemicals into different groups (<http://193.51.164.11/monoeval/grlist.html>):
 - Group 1 lists chemicals that are known to be carcinogenic to humans.
 - Group 2A lists chemicals that are probably carcinogenic to humans.
 - Group 2B lists chemicals that are possibly carcinogenic to humans.

Reproductive Toxins

"A large number of workplace chemicals, physical and biologic agents can damage the reproductive systems of both male and female workers, resulting in infertility, spontaneous abortion, developmental impairment or death in an embryo, fetus or child."

- OSHA Priority Summary Sheet on Reproductive Toxins
(<http://www.osha.gov/osinfo/priorities/reproductive.html>)

Reproductive toxins are chemicals that can cause problems with male and/or female reproduction. These problems can include fertility and gestation. Some chemicals cause problems for infants if a breast-feeding mother is exposed.

Mutagens are chemicals that cause a mutation in DNA. If the mutation occurs in germinal cells, it may affect progeny. *Teratogens* are chemicals that cause birth defects to occur in a developing embryo or fetus when the mother is exposed during pregnancy.

Chemical Sensitizers (Allergens)

An *allergy* develops when the immune system reacts to a harmless substance as if it were infectious, triggering the production of antibodies. Subsequent exposures to even very small amounts of the same substance can trigger the allergic response. The individual who has developed an allergy can manifest the allergic response as a skin rash, eye irritation, allergic asthma, or, in severe allergic reactions, anaphylactic shock that can result in death if not treated quickly enough.

There are several chemicals and classes of chemicals that can be sensitizers. Listed here are some of the more common sensitizer chemicals:

- Polyisocyanates
- Latex rubber
- Metals
- Acid anhydrides
- Formaldehyde
- Toluene
- Thioacetic acid
- Diazomethane
- Dicyclohexylcarbodiimide
- Benzylic & allylic halides
- Some phenol derivatives
- Coal tar volatiles

Chemical Storage

Chemicals should be stored so that they are separated from other chemicals with which they might react. Use the flammable, acid or base storage cabinets as appropriate.

Be careful to store temperature sensitive chemicals in appropriate refrigerators or freezers. Standard refrigerators are not appropriate for storing volatile and/or flammable chemicals. Use explosion-proof refrigerators for storing flammable chemicals.

Do not store chemicals near direct sunlight or other heat sources and avoid storing chemicals on benches, high cabinets and in chemical hoods.

Provide secondary containment for all liquids when storing or transporting chemicals.

Material Safety Data Sheets (MSDS)

A *Material Safety Data Sheet* is a detailed report about a chemical or chemical formulation. The report includes a description of the hazards associated with the chemical and how to safely handle it. MSDS's from different manufacturers may have different formats, but they are all required to have the same information. Information that must be included on an MSDS includes:

- Chemical Product & Company Information
- Information on Ingredients
- Hazards Identification
- First Aid Measures
- Fire Fighting Measures
- Accidental Release Measures
- Handling & Storage
- Exposure Controls & Personal Protection
- Physical & Chemical Properties
- Stability & Reactivity
- Toxicological Information
- Ecological Information
- Disposal Considerations
- Transport Information
- Regulatory Information

Some of the terms used in MSDS's may be unfamiliar. On the "Links" page of the VEHS web site are links to sites with definitions for many of those terms (<http://www.safety.vanderbilt.edu/>).

Where to get MSDS's

1. All manufacturers are required to supply MSDS's for the chemicals they sell. If for some reason you do not receive a MSDS for a chemical you have purchased, you can contact the company and ask them to fax the MSDS to you. Several companies now provide online access to their MSDS's.
2. VEHS provides access to an online MSDS service that can be accessed by anyone who is logged on to a VU or VUMC computer (<http://www.safety.vanderbilt.edu/>).
3. VEHS also provides links to several free online MSDS sites through the "Links" page which can be accessed through any computer with internet access.

Where to keep MSDS's

All laboratories are required to have immediate access to MSDS's for every chemical used or stored in that lab. Therefore, you must keep your MSDS's in a location that is convenient for everyone in your lab.

Container Labeling

The Lab Standard requires that all chemicals be labeled. If you transfer a chemical from the original container to a new container, you need to also label that new container with the name of the chemical. This is very important because in the event of an emergency you need to know the exact chemical name or chemical formulation you are working with so that you will know which MSDS to consult. Containers must be labeled with:

- Chemical name
- Manufacturer's name
- Health hazards
- Physical hazards
- Long & short term health effects

For frequently used chemicals, you can create your own labels for secondary containers using a word processing program and standard labels so that you can print them out as they are needed.

Hazard Warning Signs

NFPA

The National Fire Protection Association (NFPA) labeling system uses a color-coded diamond to represent four different hazards. *Red* indicates fire hazard, *yellow* indicates reactivity hazard, *blue* indicates health hazard, and *white* is used to indicate other hazards such as **W** (water reactive) or **OXY** (oxidizer). Numbers are used to rank the degree for each type of hazard:

- 4 = extreme hazard
- 3 = serious hazard
- 2 = moderate hazard
- 1 = slight hazard
- 0 = no or minimal hazard



The Vanderbilt Laboratory Hazard Sign

Vanderbilt has developed a chemical inventory/signage program called *Hazard Identification Program (HIP)*. On-campus users can access this program through <http://safetyapps.vanderbilt.edu/>.



Personal Protective Equipment, Safety Equipment & Hygiene

Routes of Exposure

The type of Personal Protective Equipment and Safety Equipment you will need depends on the potential routes of exposure for the chemicals you will be working with. There are four ways which chemicals can enter your body: *inhalation, ingestion, absorption and injection*. For our purposes, the *injection* route of entry includes not only an actual injury to the skin caused by a sharp, but also through a pre-existing injury to the skin or through a cut injury (injection) that breaks the skin during a procedure.

Eye & Face Splash protection

To prevent contamination from getting into eyes, goggles are the best choice. Safety glasses do not provide a seal around the eyes and can therefore allow droplets to fall into your eyes. Face shields are also an excellent choice for protecting the entire face from splash contamination. If you should also need eye protection from impact (such as from flying pieces of metal from a grinder or saw) or from radiation (such as from a laser), make sure the safety glasses you choose are appropriate and rated for that type of eye protection.



Skin protection

In addition to the clothes and shoes we wear all the time, we need to wear additional protective clothing such as lab coats, lab aprons or chemical resistant protective suits and chemically resistant gloves to prevent contamination of our skin. Most of the time you will not be wearing a protective suit, so avoid wearing clothes that leave large areas of skin bare, such as shorts and sandals, when you plan to work in the lab.

The skin on our hands is the most likely part of our bodies to become contaminated. When selecting gloves for use in the lab remember the following:

1. Not all gloves protect from all chemicals. You will need to make sure that the chemicals you will be handling will not degrade the gloves you plan to wear. Glove manufacturers can provide assistance in determining which gloves will work for different chemicals.
Never wear latex gloves when handling solvents.
2. Disposable gloves should not be worn all day long. Change gloves frequently.
3. Sometimes you may need to wear more than one pair of gloves; for instance, wear heavy gloves over Nitrile gloves when using large quantities of hazardous chemicals such as halogenated solvents.

For assistance in determining the best PPE to wear for the chemicals you use, consult the *NIOSH Guide to Chemical Protective Clothing* (<http://www.cdc.gov/niosh/ncpc1.html>). There are additional PPE guides available through the VEHS "Links" page under "Chemical Safety."

To reduce the likelihood of skin contamination in your laboratory, keep your lab clean. Do not leave behind chemical residues that will allow other people to become contaminated.

Ingestion Protection

To prevent accidental ingestion of chemicals:

1. Wear gloves during procedures involving chemicals.
2. Wash your hands after each procedure.
3. Never store food or beverages in the lab with chemicals.
4. Never eat or drink in the lab.

Inhalation Protection

To prevent inhalation of chemical gases, vapors, dusts or aerosols:

1. Work in a fume hood. The fume hood is your preferred engineering control defense against inhalation uptake of chemicals. Make sure the fume hood is working well before use and work at least six inches in from the edge of the hood to maximize the capture efficiency of your fume hood.
2. Glove boxes are another way to prevent hazardous chemicals exposure.
3. Wearing a respirator is the very last option to consider when providing inhalation protection.
 - a. Before anyone can be approved to wear a respirator, they must satisfy these two OSHA requirements: (1) An annual medical evaluation to determine whether or not a person is physically capable of wearing a respirator and (2) OSHA requires a fit-test evaluation to ensure that the respirator seals properly around the face and does not allow unfiltered air to leak in.
 - b. Respirator filters are chemical specific. You must make sure that the cartridges in your respirator will absorb the chemical(s) you are planning on working with.



Emergency Showers & Eye Wash Stations

If there is an accident, two of the most important pieces of safety equipment you have are the *emergency shower* and the *eye wash station*. If you contaminate yourself over a large part of your body or over a part of your body that you cannot rinse off in the sink, immediately go to the emergency shower, strip off any contaminated clothing, and stay under the water for at least 15 minutes. If something splashes into your eye, immediately flush with water for as long as possible. The general rule is to flush with water for 15 minutes.

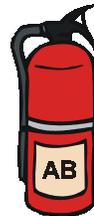
Fire & Life Safety

Classes of Fire Extinguishers

The *class* of a fire extinguisher tells you what type of fire that the extinguisher can be used on.

- A – fires involving ordinary combustibles such as wood, paper or cloth.
- B – fires involving liquids, greases & gases
- C – fires involving energized electrical equipment
- D – fires involving metals such as Mg, Na or K.

If an extinguisher is rated for multiple classes, it will work on all of the fire classes that are listed. For instance, class “ABC” fire extinguishers work for any type of fire *except* metal fires.



*This **AB** class extinguisher should not be used for metal or electrical fires.*

Using a Fire Extinguisher – PASS

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



- P**ull the pin.
- A**im at the base of the fire.
- S**queeze the handle.
- S**weep back and forth.

When using a fire extinguisher, always start 8-10 feet away from the fire and walk towards the fire as you spray it with the extinguisher. If you start too close, you can actually spread the fire. If the fire is not out by the time you get to the fire, leave; the fire is too big for you to handle. Never attempt to put out a fire that is larger than a small trash can fire.

If there is a fire – RACE

- R**escue or Remove everyone in the lab.
- A**ctivate the nearest alarm pull station.
- C**onfine the fire by closing lab doors. If it is a hood fire, you should lower the sash, if possible.
- E**vacuate – Leave lights on, follow the exit signs, stay low in smoky areas and use stairs, not elevators.



Flammable & Combustible Liquid Storage

Flammable liquids should always be stored in Underwriter Laboratories (UL) listed flammable storage cabinets and containers. Only keep small quantities (no more than 5 gallons) of combustibles in ordinary containers outside of flammable storage containers.

Open Flames

If you perform procedures involving open flames, never leave the fire unattended.

Electrical Safety

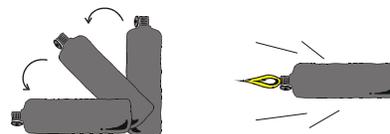


Keep electrical equipment away from damp areas, such as sinks. Use ground fault protection and arrange equipment to avoid spills. Remember that extension cords are only for short-term use. For long-term power supply, have additional outlets installed.

Compressed Gas & Cryogenic Liquid Cylinder Safety

Compressed Gas & Cryogenic Liquid Cylinders Can Become Rockets

All compressed gases and liquids, even if non-flammable and non-toxic are still potentially hazardous due to oxygen displacement and because it is under high pressure. If a cylinder is not secured properly and falls over, there is a rocket launched in your lab.



Cylinder Transportation & Storage

Use carts only when transporting and never for storage.

Always keep cylinders secured to prevent them from falling. Only secure cylinders to structural supports that are permanently affixed to the floor, wall or ceiling. It is permissible to store up to three capped cylinders together, but secure cylinders individually if they are uncapped.

Store cylinders away from potential heat sources such as incubators, water baths, hot plates or burners.

Never use or store cylinders in poorly ventilated rooms, because compressed gases and liquids can rapidly displace the oxygen in the room, leaving you vulnerable to suffocation. Conversely, oxygen cylinders that are opened in a poorly ventilated room can quickly enrich the atmosphere, creating an atmosphere where the smallest spark could easily start an explosive and deadly fire.



An additional concern when storing cryogenic liquid cylinders in a small, inadequately ventilated area is that water will condense on the floor of the room resulting in a dangerous, slippery floor.

Hazardous Gases

Hazardous gases include both toxic gases and gases that create fire hazards. Hazardous gases must be stored in vented cabinets, fume hoods, or specially designed vented equipment. Store fuel cylinders in vented cabinets, separately from oxygen cylinders.

Following is an incomplete listing of some of the hazardous gases you may use: O₂, H₂S, NH₃, NO₂, NO, HCl, HF, SO₂, H₂, acetylene and halogen gases (Cl₂, Br₂, F₂).

Cylinder Safety Tips

Before using a cylinder, verify that you have the correct gas or liquid. When installing cylinders, leak test around valve connections.

When a cylinder is empty, close the valve, check if for leaks, and remove the cylinder. Securely recap the cylinder and attach a tag or sticker that will identify the cylinder as empty.

Choose piping and fittings appropriate for the chemical and the pressures used. When designing piping layout, consider ways to minimize the likelihood of damage to the piping. Do not use adaptors and use only appropriate, compatible regulators.

Spills & Emergency Response

There is no precise definition for what makes a spill “small” or “large.” This is because the degree of hazard and toxicity among different chemicals greatly varies. In general, a “small” spill is one that you can *safely* handle yourself and a “large” spill is one that you cannot safely handle without assistance. If you have any doubts as to whether or not you can handle a spill yourself, then classify it as a “large” spill and call for help.

To respond to a small spill:

1. Evacuate anyone in immediate danger. Take care of injured people before cleaning up the spill.
2. Stop the spread of the spill as soon as possible. Use appropriate absorbent material to contain the spill.
3. Consult the Material Safety Data Sheet (MSDS) for proper decontamination procedures.
4. Call VEHS at 2-2057 or 835-4965 for guidance and if you have any doubts about your ability to safely clean up the spill.

To respond to a large spill:

1. Evacuate anyone in immediate danger.
2. Tell others in your lab to leave the area with you. Close the door after the last person has exited the room. Advise people in neighboring laboratories if there are potential hazards (such as evaporating solvents or hazardous gases) that could endanger them.
3. Phone 1-1911 and 835-4965 to report the situation. Be prepared to tell emergency responders what chemical(s) are involved in the spill.

Personnel Exposures

If a person is contaminated with a chemical, seconds can make a huge difference in the severity of injury. Make sure you know exactly where the nearest emergency showers and eye wash stations are located. Strip contaminated clothing off of the victim and have them rinse the contaminated area for at least fifteen minutes.

In case of a medical emergency, seek medical care from the VUH Emergency Department. Call for an ambulance to transport the victim if necessary.

For non-emergency conditions involving exposure to a chemical during normal business hours, call the Occupational Health Clinic at 936-0955.

All employees who work with hazardous materials will have the opportunity to receive medical attention and any follow up exams under the following circumstances:

- After a spill, leak, or explosion resulting in the likelihood of a hazardous material exposure.
 - Whenever an employee develops symptoms associated with exposure to hazardous materials.
 - Whenever exposure monitoring reveals an exposure level routinely above the Permissible Exposure Level (PEL) for an OSHA regulated substance.
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Contact VEHS

If you have additional questions, assistance and advice about laboratory safety, contact VEHS by phone (322-2057) or emergency pager (835-4965). You can also consult the VEHS web site (<http://www.safety.vanderbilt.edu/>) for additional safety information.