University of Virginia

CHEMICAL HYGIENE PLAN

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Most Recent Revision Date: January 13, 2021

Next Review Date: December 31, 2021

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Introduction

Laboratories are essential for training the next generation of scientists, engineers, and educators, and providing the infrastructure necessary for new discoveries. While modern laboratories are generally safe spaces, serious accidents can and do occur. This document provides the University of Virginia (UVA) community with an introduction to laboratory chemical hazards, information about how to reduce the risk of injuries and exposure from them, and where to obtain additional technical advice and assistance. It also serves as UVA's Chemical Hygiene Plan (CHP), as required under the U.S. Occupational Safety and Health Administration's (OSHA) standard, *Occupational Exposure to Hazardous Chemicals in Laboratories* (29 CFR Part 1910.1450), commonly referred to as the *Laboratory Standard*.

UVA is committed to providing safe laboratories and fostering a culture of safety among those who work and study in them. Since laboratories encompass an enormous diversity of materials and operations, no single document can address every possible hazard. Those who will work or study in a laboratory at UVA should become familiar with this CHP, complete required safety training, and obtain laboratory-specific safety information from the Principal Investigator, Instructor, or Laboratory Manager. A culture of laboratory safety can be achieved by encouraging an open, interactive environment where everyone feels comfortable asking questions and where mistakes are used as a means for continuous improvement and the advancement of knowledge.

Please also get to know UVA's Office of Environmental Health and Safety (EHS), an important University resource. Most of our services are free-of-charge to the UVA community, and include providing technical information and advice, specialized training, assistance in the selection and use of personal protective equipment, performing safety audits and inspections, testing and certifying safety-critical equipment, and collecting and disposing of hazardous waste. EHS welcomes your questions, comments, and suggestions.

Scope and Applicability

Although OSHA's *Laboratory Standard* technically applies only to employees, UVA extends its Chemical Hygiene Plan (CHP) to all members of the University community engaged in laboratory activities, whether they are paid or not. This includes Principal Investigators and other Faculty, Instructors, Laboratory Managers, technical staff, undergraduate and graduate students, post-doctoral positions, and approved visiting scientists, interns, and volunteers.

This CHP applies to all UVA spaces in Charlottesville and Wise, including main Grounds, UVA Health System, and field research stations operated by UVA, that meet the following OSHA definitions:

- Laboratory: A facility where the "laboratory use of hazardous chemicals" occurs. It is a space where relatively small quantities of hazardous chemicals are used on a *non-production* basis.

- Laboratory Scale: Activities where the containers and vessels used for reactions, transfers, and other processes can be readily and safely manipulated by one person.

- Laboratory Use of Hazardous Chemicals: Handling or use of hazardous chemicals under the following conditions:
    - Chemical manipulations are carried out on the laboratory scale, and
    - Multiple procedures or chemicals are used, and
    - Procedures are not part of a production process nor do they in any way simulate a production process, and
    - Protective laboratory practices and equipment are available and in common use to minimize chemical exposures.

Based upon these criteria, the laboratories at UVA that are covered by the OSHA *Laboratory Standard* and this CHP are primarily research and teaching laboratories, and those providing advanced independent study for students. Nevertheless, the safety principles introduced in this CHP are directly applicable to nearly all other UVA laboratories, with the major difference being more stringent requirements for chemical container labeling in production-oriented laboratories. Since these distinctions can often be subtle, please contact EHS if you have any questions about which rules apply to your laboratory.

Roles and Responsibilities

Although everyone at UVA shares in the responsibility for safety, the following individuals have specific roles for safety in the laboratory. Please review these responsibilities as they relate to your role and those who report to you or to whom you report.

President

The President of UVA has ultimate institutional responsibilities for all activities at the University including safety in the laboratory. The President reports to the Board of Visitors.

Vice President for Research

Programmatic responsibilities for research at the University are organizationally delegated to the Vice President for Research, including those for safety in UVA laboratories. Departments involved in guiding, regulating, or otherwise supporting basic and applied research at the University report to this position, including Environmental Health and Safety (EHS). Among other things, the Vice President for Research is responsible for ensuring adequate staffing, resources, and funding for EHS, and assisting in the enforcement of safety rules and correction of unsafe conditions.

Deans and Chairpersons

Academic Deans and Chairpersons are responsible for laboratory safety in their Schools and Departments. Their responsibilities include developing familiarity with laboratory hazards and University safety rules, and ensuring that faculty and instructors are also aware of these issues and incorporate them into their research and teaching. Deans and Chairpersons are encouraged to make safety a part of job descriptions, search committee recruitment criteria, and faculty promotion. Deans and Chairpersons may also be called upon for assistance in the enforcement of safety rules and correction of unsafe conditions.

Principal Investigators, Instructors, and Laboratory Managers

Principal Investigators, Instructors, and Laboratory Managers serve as key *laboratory supervisory personnel*, with responsibilities that include laboratory safety for which they must lead by example. They are responsible for knowledge about this program and other relevant UVA safety and regulatory requirements (including hazardous waste management) that impact their laboratory. They must also ensure that individuals in their laboratory complete required training and that they or their designee provide laboratory-specific safety training. Laboratory supervisory personnel are responsible for orienting new members of the laboratory, including volunteers, as well as any visitors or service providers. Laboratory supervisory personnel must also ensure that standard operating procedures are available or developed, appropriate personal protective equipment is provided free-of-charge and used properly, monthly emergency eyewash station checks are conducted, staff are kept up-to-date about new hazards and other

developments, and that deficiencies identified in laboratory inspections are addressed within a reasonable timeframe. Laboratory supervisory personnel are encouraged to participate or oversee periodic laboratory self-inspection.

Managers who are considering sponsoring volunteers shall refer to the UVA policy *HRM-001: Authorization and Engagement of Volunteers* for all University requirements for engaging volunteers.
Laboratory supervisory personnel are also responsible for reviewing new materials, equipment, and instrumentation with EHS and Facilities Management to ensure that they can be safely accommodated within their existing laboratory infrastructure or if modifications or supplemental controls will be needed.

Individuals in the Laboratory
Individuals who work or study in a UVA laboratory are responsible for their own safety and those around them. In order to help achieve the highest level of safety, individuals have the responsibility to:

- Complete required safety training before beginning work with hazardous chemicals or equipment, including the proper management of hazardous chemical wastes,
- Prepare for laboratory work in advance by reviewing techniques and reagents, identifying hazards, and developing written protocols that include appropriate safety procedures,
- Wear appropriate clothing and all required personal protective equipment in the laboratory,
- Follow established procedures and ask for advice and approval before undertaking new or unfamiliar procedures, using highly hazardous materials, or "scaling up" an experiment,
- Stop work if any unusual or unexpected conditions arise,
- Remove damaged equipment from use, post it as such, and share information about the problem with laboratory supervisory personnel,
- Report accidents, over-exposures, signs or symptoms of potential over-exposure, and any observed unsafe conditions as soon as possible to laboratory supervisory personnel, EHS, or their UVA healthcare provider.

Environmental Health and Safety (EHS)
EHS is the principal source of safety and health information, technical assistance, and advice for the UVA community. Most services are free-of-charge and available during regular business hours as well as off-hours in the event of a spill emergency. Regarding chemical laboratory safety, EHS:

- Maintains and administers this Chemical Hygiene Plan and related laboratory safety programs, including annual reviews and revisions,

- Designates a Chemical Hygiene / Safety Officer to administer these programs,
- Communicates with the UVA laboratory community about new hazards and any changes to safety policies or programs,
- Serves as a technical resource to the UVA laboratory community,
- Periodically inspects all laboratories,
- Develops and provides relevant laboratory chemical safety training,
- Manages the testing and certification of chemical fume hoods and other equipment as deemed appropriate
- Performs exposure assessments and monitoring, when appropriate,
- Provides specialized emergency spill response services,
- Investigates accidents, incidents, and near-misses.

Facilities Management and Contractors

Facilities Management (FM) staff and contractors provide essential services to UVA laboratories, including design, renovation, maintenance, and repair. These individuals periodically require access into laboratory spaces for both planned and emergency work. To the extent feasible, they should work with supervisors or UVA project managers to inform laboratories when an impairment to a critical laboratory safety system will occur, including planned and unplanned shutdowns, repairs, or upgrades. Off-hours and at other times when laboratories may be unoccupied, they should use the Hazard Communication Door Sign to identify any unusual hazards and call the laboratory emergency contact(s) if needed. FM employees should follow FM's Occupational Health and Safety guidance and procedures for basic safe laboratory access. If needed, consult EHS for additional guidance.

Police

UVA Police provide 24/7 emergency response services for all UVA facilities on grounds, including laboratories. Police are responsible for receiving emergency calls and other communications on grounds, notifying additional responders as appropriate, and providing physical control of the accident or emergency scene

Healthcare Services

Urgent medical needs will be addressed by the first responders on-scene during any emergency. Non-emergency medical services and assistance with any other health issues related to laboratory operations are provided by UVA-WorkMed, Employee Health for the UVA Health System, Student Health on Main Grounds, and UVA Student and Employee Health-Wise Clinic for those at the College at Wise.

Visitors, Interns, and Volunteers

Visitors from other institutions and internship participants should receive approval from their sponsoring UVA faculty or department before working in a UVA laboratory. Sponsoring UVA

faculty and staff shall formally review and document volunteers, as per UVA policy *HRM-001: Authorization of Volunteers*, and seek formal authorization applicable to host Department or School requirements. Refer to the EHS webpage for a listing of prohibited activities and additional guidance for volunteers with potential exposure to hazardous materials, environments and/or equipment.

Any individual handling chemicals and/or generating hazardous waste in a laboratory or other instructional environment at UVA must complete UVA's chemical safety and waste training on-line. The Principal Investigator or other sponsor is responsible for obtaining temporary computing ID credentials for access to on-line training. Laboratory supervisory personnel must also orient new persons to their laboratory and provide specific information about hazards, procedures, and safety measures, including personal protective equipment and emergency plans and procedures.

Planning to Work at Another Institution?

Members of the UVA community periodically visit laboratories at other institutions to learn new techniques or work with collaborators. While UVA training will prepare you to safely work at most other institutions, you should inquire as early as possible about the host institution's laboratory safety training requirements. In general, you can save time and avoid delays by completing any required on-line courses in advance. Upon arrival, be certain you receive a formal introduction and orientation to the laboratory, who to contact for questions and advice, and how to protect yourself from hazardous materials and equipment. In the event you observe any unsafe conditions or practices, speak up and ask questions. If you remain uncomfortable with the situation or still have any questions or concerns, please contact your laboratory supervisor or EHS back at UVA for help.

Coming to UVA?

New UVA faculty who will work in a laboratory should contact EHS prior to or upon arrival for guidance and assistance on safety requirements and considerations for setting up the laboratory. New faculty are encouraged to schedule an in-person on-boarding meeting with the UVA Chemical Safety Officer - contact EHS for more information.

Minors

Individuals under the age of 18 should not be in a UVA laboratory unless they are matriculated as a UVA student, an approved volunteer, or part of an approved University tour, exhibition, demonstration, workshop, or internship. Minors under the age of 16 may not serve as volunteers without approval in writing from the Office of Property & Liability Risk Management. Younger persons may be more susceptible to effects of certain hazardous materials, and may be less aware and too inexperienced to recognize potential risks and hazards. Local, state and/or federal regulations, University policy, and University Safety Committees explicitly prohibit minors from

potential exposure to certain hazardous materials and/or equipment (e.g., certain biological agents, radiation and radioactive materials, carcinogens, acutely toxic chemicals). Therefore, it is essential for their sponsor to review the planned laboratory experience in advance with the Departmental Chairperson, referring to the EHS webpage for a listing of prohibited activities and additional guidance.

Pets

Pets are strongly discouraged in or near any laboratory, however the UVA Institutional Animal Care and Use Committee (IACUC) prohibits companion animals in vivaria and all animal research laboratories designated in an IACUC protocol. In the rare circumstance that an individual requires a *bonafide* service animal in order to work in a laboratory, the service animal should only be brought into the laboratory after specific permission is obtained from the responsible Principal Investigator or laboratory supervisor.

Training and Information

Training

Everyone using chemicals at UVA has the right to be informed of the hazards, effective control, and procedures for safe use of them. Individuals in a laboratory must also be informed of OSHA's *Laboratory Standard* and this Chemical Hygiene Plan (CHP), and they must complete laboratory chemical safety training that includes hazardous waste management. Those individuals are required to take the UVA online module *Chemical Safety and Waste Training for Research Personnel and Students*. This basic introduction to laboratory chemical safety and hazardous waste management must be supplemented with laboratory-specific information. On-going training should occur during laboratory meetings and whenever new chemicals, equipment, or procedures are introduced. Refresher training should also be provided after any accident, over-exposure, spill, or release. EHS's online application known as the *Safety, Training, and Recordkeeping* (STAR) system can be used to document training provided locally in laboratories and other work units.

Online safety training modules are also available for other laboratory subjects, including *Chemical Storage, Compressed Gas Cylinder and Regulator Safety*, and *Handling Organolithiums and Related Agents*. Contact EHS or review their website for the latest listing of online training and other informational materials.

Visiting faculty and other non-UVA collaborators, students, interns, or volunteers can obtain a temporary computing account in order to complete required EHS training modules and access other resources that are protected by NetBadge. To obtain an account, contact your UVA sponsor to arrange for the affiliated School or Department to submit a service request on your behalf with UVA's Information Technology Services.

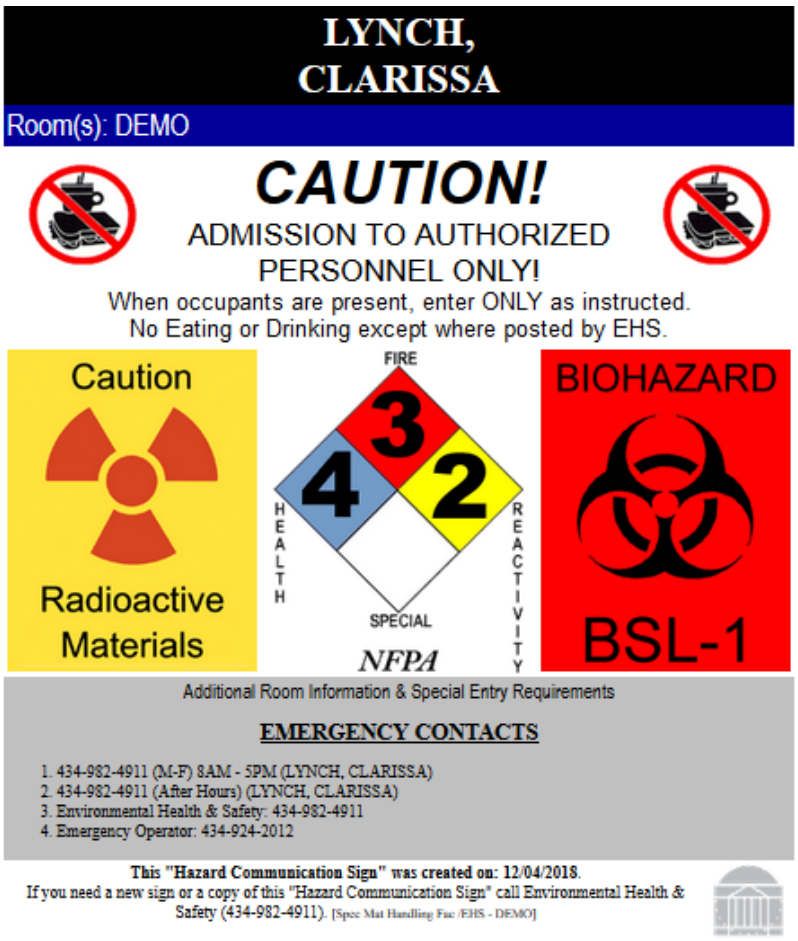
Additional Sources of Information

In addition to this CHP, information about chemicals is also provided or made available to the UVA community through:

- Laboratory Hazard Communication Door Signs,
- Chemical container labels,
- Safety Data Sheets, and
- EHS professional staff, website, and reference materials.

Laboratory Door Signage

Every laboratory must be posted with a UVA Hazard Communication Door Sign (see below). These standardized signs were developed in consultation with local fire officials to quickly convey information about hazardous materials and conditions inside each laboratory and provide emergency contact information. Laboratory supervisory personnel are responsible for keeping door signs accurate and up-to-date – contact EHS for help with new signs.



Chemical Container Labels

Container labels are an important source of information about chemicals. All chemical containers must be labeled, and those on incoming products must not be removed or defaced. Since full implementation of the United Nation's Globally Harmonized System of Classification and Labeling of Chemicals (GHS) in 2015, labels on new chemical containers must also include specific warnings known as signal words, hazard statements, precautionary statements, and safety pictograms. Older containers of chemicals may remain in use as they are, but laboratories are encouraged to supplement the labels on particularly hazardous substances – contact EHS for assistance.

Safety Data Sheets

Safety Data Sheets (SDSs) are informational documents that chemical manufacturers, suppliers, and importers must provide for all hazardous chemicals. Formerly known as Material Safety Data Sheets, the required content of SDSs was also revised with full implementation of the GHS in 2015. SDSs are generally the most convenient and accessible source of initial information about the physical and health hazards of a chemical or chemical product, signs and symptoms of potential over-exposure, methods to minimize exposure, and emergency response procedures. It is important that everyone who works with chemicals and chemical products at UVA understands what SDSs are, how to access and read them, and where to get additional information.

SDSs must address 16 required sections using the following standardized format:

1. Product and Company Identification: product identifier or name, manufacturer or distributor contact information, emergency phone number, recommended use(s), and any restriction(s) on use.
2. Hazards Identification: hazards regarding the chemical and required label warning elements.
3. Composition/Information on Ingredients: information on chemical ingredients and any trade secret claims.
4. First Aid Measures: acute and delayed symptoms / effects of over-exposure, recommended treatments for victims.
5. Fire-Fighting Measures: suitable fire extinguishing techniques and equipment, chemical and physical hazards from a fire involving the chemical.
6. Accidental Release Measures: emergency procedures, recommended personal protective equipment, and proper methods for containment and cleanup.
7. Handling and Storage: precautions for safe storage and handling, including any incompatibilities with other chemicals, temperature extremes, etc.

8. Exposure Controls / Personal Protection: OSHA and other relevant occupational exposure limits, appropriate engineering controls, and recommendations for personal protective equipment.
9. Physical and Chemical Properties: key properties of the chemical.
10. Stability and Reactivity: description of chemical stability and potential hazardous reactions under normal conditions.
11. Toxicological Information: likely routes of exposure, potential health outcomes from over-exposure, toxicity data from research animal studies for dermal, inhalation, and ingestion administration.
12. Ecological Information: environmental and ecological toxicity data, especially release to aquatic systems.
13. Disposal Considerations: guidance on chemical waste disposal.
14. Transportation Information: guidance on shipping and transporting the chemical.
15. Regulatory Information: additional references to US and international regulations for the chemical.
16. Other Information: other relevant information, including date of SDS preparation or last revision, references to additional information.

EHS and the Medical Center's Environment of Care Division have partnered to provide the UVA community with access to SDSs through a searchable, web-based SDS database. This service is available to everyone at UVA using NetBadge (http://ehs.virginia.edu/msds/). If you are not able to find an SDS for a chemical contact EHS for assistance.

Environmental Health and Safety (EHS)

EHS is also an important University resource for information on hazardous chemicals, laboratory safety, protective equipment, hazardous waste, and related subjects. EHS maintains safety and health references and resources both online and in paper form, including copies of this CHP. If you have any questions or need assistance, please call EHS at (434) 982-4911. For a chemical spill after-hours, call the same number and then hit "0" when prompted to reach the University emergency operator. In the event of a life-threatening or serious emergency at any time, contact the police by dialing 911 from any phone.

Other References and Resources

Additional chemical safety information is available, including the items listed in the section *Key References and Other Resources*. One of the more comprehensive references on chemical and laboratory safety is the National Research Council's *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*. First published in 1981, it has since been updated and expanded. A PDF copy of the latest edition is available from EHS; it can also be accessed online or in print form through the UVA library.

Laboratory Design, Construction, and Maintenance

Laboratories at UVA are designed and constructed to meet state and local building, life safety, and fire codes. They are also designed to achieve best practices within higher education in the areas of energy conservation, safety, and accessibility. Facilities Management and Health System Physical Plant has key responsibilities for these areas; specific laboratory requirements are described in UVA's *Facility Design Guidelines*.

Some of the more critical laboratory safety features involve ventilation (both general room and local exhaust systems), emergency water systems for eyewashes and showers, fire/smoke detection and suppression, security and access control, back-up and alternate power, and adequate storage for hazardous materials.

Security and Access Control

Only authorized members of the UVA community and approved visitors, interns, and volunteers may have access to laboratories and hazardous materials. These spaces must be lockable and kept locked when unoccupied. Keys, door lock codes, and UVA ID cards may not be shared.

Emergency Water Systems

UVA laboratories with corrosive chemicals or other substances injurious to the eyes or body must have an emergency eyewash and shower. Per UVA's *Facility Design Guidelines*, this equipment must meet ANSI/ISEA Standard Z358.1, *Standard for Emergency Eyewash and Shower Equipment*, including immediate single-handed activation and sufficient continuous water flow until shut-off. Emergency water devices must be prominently posted and located within as short a distance as possible, preferably within 50 feet without obstruction. Emergency showers (regardless of location) and eyewashes in public corridors are tested annually by Facilities Management. Eyewashes in laboratories are tested by EHS during periodic laboratory inspections; they must also be tested by laboratory staff at least monthly. Consult EHS with any questions about these devices in your laboratory.

Laboratory Ventilation

Although chemical fume hoods are the primary engineering control for capturing and removing airborne contaminants in most laboratories, general room ventilation also plays an important role by minimizing the build-up of fugitive emissions, reducing odors, and exhausting spills and other accidental releases. Per UVA's *Facility Design Guidelines*, laboratory ventilation systems must meet applicable building codes and best practices established by the American Conference of Governmental Industrial Hygienists and American National Standards Institute. To protect against the re-distribution of airborne contaminants, laboratory room air is generally 100% exhausted and not recirculated elsewhere in a building. Exceptions may be permissible for special laboratory facilities after EHS review and approval.

Many different styles of chemical fume hoods and other local exhaust ventilation devices have been installed at UVA. These devices are designed to capture and exhaust harmful gases, vapors, aerosols, mists and other contaminants directly from the work area, and are 100% exhausted from buildings. So-called recirculating chemical fume hoods are not permitted without EHS review and approval. To help ensure user awareness of device operating status, chemical fume hoods are equipped with air flow or face velocity monitors. EHS is responsible for inspecting, testing, and certifying chemical fume hoods and other laboratory local exhaust devices annually, as well as providing oversight on new devices.

Chemical fume hoods are the primary local exhaust device found in most UVA laboratories, but they are also the principal source of energy consumed in most laboratory buildings. UVA has pursued a number of efforts to conserve or reduce energy use from chemical fume hoods, including installing variable air volume control systems, switch controls for specific low hazard spaces (i.e., Curry School of Education teaching laboratory), heat recovery systems, and the deployment of lower flow / "high performance" hoods.

Fire / Smoke Detection and Fire Suppression

UVA laboratories are designed and constructed to meet the Virginia Building and Fire Codes, and their fire protection systems are maintained by UVA's Facilities Management and Health System Physical Plant. All laboratory buildings are equipped with fire detection and fire suppression devices. Dry powder Class ABC portable fire extinguishers and deluge water sprinklers are the most common means of fire suppression. This equipment is generally appropriate for most laboratories, but some specialized optical and electronic facilities may be seriously damaged by fine dry powder or water. Clean / dry agent fire suppression substitutes are available; consult EHS for more information.

University Utilities

Modern laboratories are highly infrastructure-dependent and require uninterrupted utility service. UVA laboratories on grounds are heated and cooled by multiple University utility plants, along with access to portable air-cooled chillers mounted on trailers for emergency, standby, or supplemental cooling when needed. Three electric substations serve UVA in Charlottesville. These substations are equipped with redundant service feeds from the electric utility company, which significantly increases service reliability. Buildings at most UVA locations also have emergency generators to provide back-up power for critical systems.

Breakdowns to utility services can cause serious disruptions to on-going research, and extended failures in some laboratories can result in irreparable damages to and loss of equipment, infrastructure, and unique collections of specimens. Laboratories with critical operations are encouraged to discuss their utility requirements (including emergency and alternate electrical power) with Facilities Management.

Hazards of Chemicals

This section provides an introduction to the hazards of chemicals and routes of exposure to them in the laboratory. Additional information on these subjects is available in the *Key References and Other Resources* and *Glossary of Terms and Definitions* sections of this Chemical Hygiene Plan (CHP), and is also discussed in UVA's online chemical safety and waste training.

Chemical Hazards

Hazards are the inherent harmful characteristics or properties of a substance, operation, or activity, regardless of the quantity involved or method of use. Chemicals can pose a variety of hazards to human health and physical injury, including:

Health Hazards	**Physical Hazards**
Toxic	Combustible
Carcinogenic	Flammable
Mutagenic	Explosive
Reproductive toxins	Reactive or pyrophoric
Sensitizers	Oxidizers
Irritants and Corrosives	Corrosive
Asphyxiants	Compressed gases and liquids
	Cryogenic liquids

Some chemicals pose both health and physical hazards. For example, inhalation of benzene vapors can result in central nervous system narcosis, direct skin contact can defatten skin, and long-term exposure has been demonstrated to increase the rate of leukemia. As a flammable liquid, benzene can also result in serious burns or cause a structural fire if it is accidentally ignited.

Routes of Exposure

Chemicals exert harmful effects on the body through exposure by one or more of the following routes:

- Ingestion,
- Inhalation,
- Dermal (skin) contact,
- Percutaneous (puncture).

Ingestion refers to eating or drinking a substance and can also include, to a lesser extent, swallowing mucous containing a substance that was inhaled into the upper respiratory system. Ingestion is the most common route of poisoning in homes with small children, but is rare in

laboratory settings due to long-standing restrictions on smoking, eating, or drinking. Individuals handling hazardous materials must nevertheless still take precautions against inadvertent ingestion by carefully controlling contamination, especially on the hands.

Inhalation and dermal (skin) contact are the more common routes of chemical exposure in most laboratories. Inhalation can generally be controlled effectively through the use of a local exhaust ventilation device such as a chemical fume hood or exhaust snorkel when handling volatile substances or performing operations likely to splash or aerosolize. Dermal contact can be limited through careful work practices that minimize contamination such as the use of tongs or forceps, good housekeeping, and the proper selection and consistent use of gloves.

Percutaneous exposures occur when intact skin is punctured by a sharp or pointed object and contamination on the object is introduced into the body. These so-called "Sharps" injuries not only physically damage tissue but are also responsible for a large proportion of laboratory- and clinically-acquired infections. Within chemical laboratories, puncture wounds and percutaneous exposures can be minimized by:

- Replacing sharp needle syringes with blunt cannula devices,
- Eliminating Pasteur pipettes,
- Substituting safety blades and scalpels for straight-edge razors,
- Using forceps for collecting broken glass or dropped needles and syringes,
- Adopting one-handed techniques and not recapping needles.

While the hazards of a particular chemical reflect inherent properties of the chemical, the actual risk of injury or illness is a function of both hazard and exposure. Regardless of the route, the exposure may consist of a brief or even one-time (acute) exposure, or it may repeatedly occur over longer (chronic) periods of time. Efforts that minimize or eliminate exposure will limit risk of harm.

Signs and Symptoms of Over-Exposure

Information about the hazardous properties of chemicals, including typical medical signs and symptoms of over-exposure, is available from container labels, Safety Data Sheets, and other references and resources.

The signs and symptoms of over-exposure vary widely by the chemical, concentration, route of exposure, and individual health and medical conditions. In addition, over-exposure to many chemicals may not result in immediately recognizable signs or symptoms. However, should any of the following signs or symptoms develop, individuals should stop work immediately, remove personal protective equipment, wash their hands, and contact their UVA Healthcare provider:

- Unusual taste or odor,
- Respiratory irritation, coughing, choking, or shortness of breath,
- Sudden headache, dizziness, blurred vision, or loss of consciousness,
- Burning or painful sensation,
- Swelling, reddening, or itching skin.

Particularly Hazardous Substances

OSHA's *Laboratory Standard* identifies Particularly Hazardous Substances as several categories of chemicals that pose serious and potentially irreversible health hazards. They include select carcinogens, reproductive toxins, and acutely toxic chemicals. Due to their significant potential for harm, work with these substances requires adoption of additional safe working practices to further control exposure. Please contact EHS for help in identifying Particularly Hazardous Substances or for assistance in evaluating the hazards from these or any other chemicals.

Select Carcinogens

Select carcinogens are the subset of chemicals known or reasonably anticipated to cause cancer in humans based upon epidemiological research or animal testing. They include chemicals identified by the International Agency for Research on Cancer and the National Toxicology Program, and also those specifically regulated as carcinogens by OSHA.

Reproductive Toxins

Reproductive toxins are those chemicals that can negatively affect human reproduction or reproductive capabilities. They include chemicals that can damage reproductive organs or their function, cause mutations to inheritable genetic material (mutations in sperm or egg), or cause malformations to a developing embryo or fetus (teratogenesis).

Acutely or Highly Toxic

Acutely or highly toxic chemicals are chemicals that cause serious illness or death after exposure to small quantities or at low concentrations.

Other Regulated or High Hazard Chemicals

In addition to the Particularly Hazardous Substances specifically addressed by OSHA's *Laboratory Standard*, many other chemicals pose serious hazards or carry special regulatory requirements. Some of the more common ones at UVA are described below.

Toxins

Toxins are widely used in biomedical research, especially those of biological origin such as botulinum, ricin, saxitoxin, and tetrodotoxin. Due to their high toxicity and potential for harmful misuse, many are regulated by the *Federal Select Agent Program*. Select agent toxins include toxic materials and toxic products from biological organisms and recombinant or synthesized

molecules. Select agent toxins can pose a severe threat to public health, animal or plant health, or animal or plant products. Small quantities of certain select agent toxins are exempt from most regulatory requirements, but laboratories interested in working with these or any other highly active toxins must first consult EHS and UVA's Institutional Biosafety Committee. Current listings of select agent toxins can be obtained from EHS or from the *Federal Select Agents Program* website.

Another important neurotoxin with increasing laboratory use is *1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine* (MPTP). MPTP is a potent neurotoxin used to induce a model of Parkinson's disease in research animals. Accidental human exposure can produce irreversible and severe brain damage from needle sticks, skin contact, or inhalation of aerosolized droplets.

Hydrogen Fluoride and Hydrofluoric Acid

Hydrogen fluoride and hydrofluoric acid can cause severe, penetrating burns to the skin, eyes, and lungs. Although concentrated forms of these compounds are readily perceived by a burning sensation, more dilute forms may be imperceptible for hours, potentially leading to insidious and difficult-to-treat deep burns.

Heavy Metals

a. Heavy metals are toxic in most forms and some, in their organic form, are extremely toxic and highly permeable to most gloves and other personal protective equipment (e.g., dimethyl mercury, tetraethyl lead).

Highly Reactive and Explosive Compounds

Highly reactive compounds include chemicals that are unstable and capable of self-decomposition or that react violently when exposed to water, humid air, oxygen, light, heat or friction, physical shock, or other chemicals. These reactions are highly exothermic and may also evolve toxic or flammable gases. They include water / air reactive and pyrophoric chemicals, azo compounds, peroxides, and peroxide-forming chemicals. Some highly reactive compounds are shipped and stored under mineral oil, solvent, or an inert atmosphere to minimize the potential for contact with air or water.

Alkali metals (e.g., sodium, potassium), some metal hydrides (e.g., lithium aluminum hydride, calcium hydride), and pyrophoric chemicals (e.g., organo-lithium compounds) react violently when exposed to water, humid air, or oxygen. Pyrophoric materials often react so rapidly that actual ignition occurs. Depending upon the location of work and the other chemicals in use, unexpected ignition can result in serious fires and life-threatening burns. Note that EHS provides an on-line training module specifically on *Handling Organolithiums and Related Agents*, available through the STAR training portal.

Explosives are a broad category of chemicals with the potential to release such large amounts of gas that they generate a high pressure shock wave capable of causing serious physical damages. Explosives can be initiated by mechanical impact, heat, light, or chemical reaction. In the laboratory, explosives may be under purposeful study but are more commonly encountered as accidental by-products, residues, or decomposition products containing explosive functional groups. Since there are dozens of different functional groups potentially capable of generating explosive compounds, consult additional technical references (especially the latest editions of the National Research Council's *Prudent Practices in the Laboratory* and Bretherick's *Handbook of Reactive Chemical Hazards*) and EHS for any questions about these materials.

Azo compounds and peroxides are highly sensitive to physical shock, heat or friction, and sparks. Many require storage below room temperature. Some common laboratory chemicals can also form potentially explosive peroxides over time, even when stored in sealed containers. Manufacturers add special inhibitors to some of these compounds to help retard peroxide formation. The table below describes the three generally recognized classes of peroxide-forming chemicals and provides some common laboratory examples of each. Additional information on peroxide-forming chemicals and their safe management is available from Safety Data Sheets, technical references (National Research Council's *Prudent Practices in the Laboratory* and Bretherick's *Handbook of Reactive Chemical Hazards*), and EHS.

Class A	**Class B**	**Class C**
Chemicals that form explosive levels of peroxides without concentration	Chemicals that form explosive levels of peroxides upon distillation or evaporation	Unsaturated monomers that can autopolymerize if inhibitors have been removed or depleted
Butadiene	Cumene	Acrylic acid
Chloroprene	Cyclohexene	Butadiene
Isopropyl ether	Diethyl ether	Ethyl acrylate
Potassium amide	Dioxane	Methyl methacrylate
Sodium amide	Furan	Styrene
	Tetrahydrofuran	Vinyl acetate

Peroxide-forming chemicals should be purchased in amber bottles and stored under dark conditions. In general, the preferred method for safe management of these chemicals is to purchase them in the smallest quantity needed, date label their containers, and discard them as hazardous waste before the manufacturer's expiration date. Class A compounds should be disposed of within 3 months of receipt; Class B and C compounds can generally be stored for longer periods of time but should be visually inspected at least every 6 months. Consult with EHS for recommended peroxide testing procedures.

Perchloric acid, picric acid, and sodium azide are three additional chemicals that are frequently found in laboratories and can pose serious explosion hazards. Unlike many of the reactive

compounds described above, these three chemicals pose little risk of explosive reaction *when kept wet* by solution in water. When dried, however, their residues (as perchlorates, picrates, and azides) can become shock, friction, and heat sensitive, and frequently accumulate under bottle caps over time.

Controlled Substances

Controlled substances are drugs, drug-like substances, and certain precursor materials that are regulated by the U.S. Drug Enforcement Administration (DEA) and also by the Virginia Board of Pharmacy (VBP). They are materials with the potential for misuse as "recreational drugs" (e.g., stimulant, depressant, or hallucinogenic effects) or as performance-enhancing steroids and steroid-analogs. There are five categories ("Schedules") of controlled substances under federal law, which the VBP has adopted along with a sixth schedule unique to Virginia. Schedule I compounds are the most highly regulated controlled substances as they, by definition, have no currently accepted medical use; requirements for the possession and use of other schedules of controlled substances are progressively less stringent. Researchers planning work with Schedule I-V controlled substances must first obtain *Practitioner* registrations from both the DEA and VBP, and meet specific laboratory security, inventory control, and user authorization requirements. Schedule VI controlled substances only require registration with the VBP. Current lists of controlled substances and registration requirements are available from the DEA and VBP websites; additional information about controlled substances may also be obtained by contacting UVA's Center for Comparative Medicine and the Office of Animal Welfare.

Chemicals of Interest - Department of Homeland Security

Several hundred chemicals are regulated under the U.S. Department of Homeland Security's (DHS) *Chemical Facility Anti-Terrorism Standards* (6 Code of Federal Regulations Part 27). Commonly referred to by its acronym, *CFATS*, this regulation addresses specific "chemicals of interest" to help protect against purposeful or accidental release, theft, diversion, or sabotage. Many university laboratories, including some at UVA, contain chemicals of interest. DHS has established screening threshold quantity limits for each of the chemicals of interest under different accident or terrorist scenarios. Despite relatively high threshold quantities for most chemicals of interest, those for some corrosive or highly toxic compressed gases as well as some other common reagents (e.g., nitric acid, sodium azide, sodium nitrate, cyanides) can exceed institutional aggregate limits. Chemicals of interest must be kept secure from unauthorized access. Copies of the current list of DHS chemicals of interest can be obtained from the *CFATS* website or by contacting EHS for more information.

Compressed Gases

Compressed gases refer to gases and some liquids contained within a vessel at pressures significantly higher than the surrounding atmosphere. Most laboratory compressed gases have internal cylinder pressures on the order of thousands of pounds per square inch (PSI), making them

a potentially catastrophic physical hazard in the event of cylinder rupture, valve failure, or another event that results in rapid loss of contents. The large quantities of material that can be stored compressed in a cylinder and their ability to rapidly diffuse in air can also make them significant health hazards. Compressed gases can present any of the health or physical hazards associated with chemicals.

The table below outlines some basic properties of compressed gases commonly used in the laboratory.

Gas	UN Number	Density (air = 1)	LEL (%)	Primary hazard(s)	Regulator
Acetylene	1001	0.91	2.5	Flammable, simple asphyxiant	510
Ammonia, anhydrous	1005	0.60	15	Corrosive, toxic	705
Argon	1006	1.38	None	Simple asphyxiant	580
Carbon dioxide	2187	1.53	None	Simple asphyxiant	320
Carbon monoxide	1016	0.97	12.5	Flammable, toxic	350
Helium	1046	0.14	None	Simple asphyxiant	580
Hydrogen	1049	0.07	4.0	Flammable, simple asphyxiant	350
Hydrogen chloride	1050	1.27	None	Highly corrosive, toxic	330
Methane	1971	0.56	5.0	Flammable, simple asphyxiant	350
Neon	1065	0.70	None	Simple asphyxiant	580
Nitrogen (3500 / 6000 PSI)	1066	0.97	None	Simple asphyxiant	580 (680/677)
Oxygen	1072	1.12	Oxy	Oxidizer	540

In terms of gas properties:

- Density refers to the relative density of the gas once released into room air. Those greater than 1 are heavier than air and will tend to accumulate at low levels while those below 1 are lighter than air and will rise.
- LEL is the lower explosive limit, the lowest concentration at which the gas can form a flammable or explosive mixture in air.
- Primary hazards are briefly listed – consult Safety Data Sheets and manufacturer technical sheets for more specific hazard information.
- Regulator refers to the specific threading and construction type of the regulator that must be used for each given gas; ultra-high purity gases often require a different regulator. Regulators are specified by the Compressed Gas Association (CGA).

Additional information about compressed gases is covered in the sections *Safe Management of Chemicals* and *Good Work Practices*, UVA's chemical safety and waste training, and from the EHS on-line module, *Compressed Gas Cylinder and Regulator Safety.*

Cryogenic Liquids

Cryogenic liquids are extremely cold liquids that pose a risk of serious tissue damage from immersion or splash contact. Their very high liquid-to-gas expansion ratios can also pose an asphyxiation hazard from oxygen displacement, cause explosion-like events when sealed containers are rapidly warmed up, or result in fires and explosions from the uncontrolled release of a flammable cryogenic liquid (e.g., liquid hydrogen). The table below summarizes the properties for some of the more common cryogenic liquids used in laboratories.

Properties of Common Cryogenic Liquids				
Liquid Cryogen	**UN Number**	**bp (°F)**	**bp (°C)**	**Liquid : Gas Expansion Ratio**
Argon	1066	-309	-185	1 : 860
Helium	1963	-452	-268	755
Hydrogen	1966	-423	-253	860
Neon	1913	-411	-246	1,445
Nitrogen	1977	-321	-196	696
Oxygen	1073	-297	-183	860

Personal Protective Equipment and Attire

Personal protective equipment (PPE) refers to garments and devices worn to protect the human body from exposure to hazardous materials. Since no single article of PPE is protective against all hazardous materials or conditions, its proper selection, use, and maintenance is critical. At UVA, laboratory PPE should be selected on the basis of anticipated hazards identified through a Hazard Assessment Survey (Safety Procedure 14-5) and guidance in the attached table. PPE must meet or exceed the certifications and requirements established from applicable regulatory or advisory agencies, and be made available free-of-charge and in a range of sizes and styles to fit everyone in the laboratory. Those wearing PPE must also receive training on: when and how to use it, how to care for the equipment, equipment limitations, and when to take it out of service. As important as PPE is for laboratory safety, however, if a more effective method of exposure control is available, it should be used instead, e.g., handling volatile chemicals inside a chemical fume hood rather than wearing a respirator and working with them at the open bench. Consult EHS for any questions about PPE.

Clothing and personal attire also play an important role in controlling exposures, minimizing contamination, and enhancing the effectiveness of PPE. Those working in a laboratory at UVA are advised to:

- Wear closed-toe, non-absorbent slip-resistant footwear and clothing that covers the legs,
- Remove or secure long or dangling jewelry, loose clothing, and scarves.
- Contain or restrain long hanging hair and beards,

Eye Protection

Eye protection must be worn in laboratories where hazardous materials are stored or used. For most laboratories, this means safety-rated glasses with side shields. Eye protection should be upgraded to fully enclosing safety goggles or by adding a faceshield whenever handling larger quantities of chemicals or performing procedures with elevated risk of splashing or flying particles. Safety eyewear and face protection used at UVA must meet the requirements in the latest version of ANSI Standard Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices.*

Regular glasses with corrective lenses are not a substitute for safety glasses, although they may be worn under safety glasses or goggles designed to cover prescription glasses, or under a faceshield. Individuals who wear corrective lenses and plan a career in the laboratory may consider procuring prescription safety glasses.

UVA strongly discourages wearing contact lenses in the laboratory. In the event of a chemical splash or flying object, contact lenses can trap material behind them and make flushing very

difficult. In addition, certain chemicals can degrade plastic contact lenses and fuse them to the cornea.

For work with laboratory equipment that generates other potential eye or face hazards such as intense light, infrared or microwave radiation, lasers, etc., contact EHS for additional guidance on protective measures.

Hand Protection

Dermal contact is among the most common route for exposure to chemicals in the laboratory. As for PPE in general, no single glove provides protection against all chemicals or physical agents. General recommendations for glove selection are provided below; more detailed chemical-specific information is available from glove manufacturers, Safety Data Sheets, EHS training module *Glove Selection*, and by contacting EHS directly.

Style and Membrane	Typical Uses
Disposable Exam - Nitrile	Incidental chemical contact or to protect specimens from enzymes on skin. Excellent dexterity, comfortable to wear, and inexpensive.
Utility - Nitrile	Contact or short duration immersion with most solvents, oils, and some corrosives
Utility - Butyl	Contact or short duration immersion with most aliphatics, halogenated solvents, aromatic hydrocarbons, mineral acids, ketones
Utility - Neoprene	Contact or short duration immersion with oils, most acids and bases, alcohols
Utility - PVA (Polyvinylalcohol)	Contact or short duration immersion with aromatics and chlorinated solvents
Utility - Teflon	Contact or extended duration immersion with nearly all chemicals. Very poor dexterity – may need to be worn under other gloves.
Kevlar	Handling sharp objects
Heavy Leather or Insulated	Extremely hot or cold objects, cryogen handling, sparks

For incidental contact with low hazard substances or to protect specimens from possible skin / hand contamination, “examination-style” gloves are commonly worn in the laboratory. Exam gloves are thin, disposable gloves meant for single use. They were traditionally manufactured from latex rubber but concerns over latex skin allergies have resulted in alternative formulations, with nitrile rubber now the most common membrane. Although nitrile rubber is inherently more resistant to a wider range of chemicals than natural latex, the thinness of any exam style glove means that they should not be worn where direct chemical contact or immersion is expected. Double gloving can provide some additional protection, but it is generally preferable to wear a pair of heavier, longer “utility grade” gloves over exam gloves for direct contact or immersion. Utility grade gloves are available in a range of thicknesses and membranes, with nitrile,

neoprene, and butyl rubber among the more useful, along with Teflon gloves. Other specialty gloves include Kevlar puncture- and cut-resistant gloves, Nomex and other non-combustible fibers for high heat and open flame work, and insulated gloves for work with hot objects and cryogenic liquids.

Body Protection

Along with safety glasses and gloves, a good quality, properly-fitted laboratory coat completes the basic PPE ensemble in most laboratories. All cotton or high cotton content blend laboratory coats offer protection against common laboratory substances and are less susceptible to burning than many synthetics. Disposable Tyvek or coated Tyvek laboratory coats offer better chemical resistance; they are recommended for certain activities with Particularly Hazardous Substances and can be discarded as hazardous waste upon completion of work.

Special flame resistant ("FR") laboratory coats or smocks should be worn where sparks or open flames larger than Bunsen burner scale are present, and for all operations involving pyrophoric materials or water / air reactive substances. Rubberized splash aprons may also be worn for handling larger quantities of corrosives, while fully encapsulating suits or coveralls may be required in some areas (e.g., cleanroom).

Respiratory Protection

Respirators are generally not needed in laboratories due to the small quantities of chemicals handled and the use of chemical fume hoods and other local exhaust ventilation devices. However, there are some activities where a respirator is necessary or desirable. Since respirator use places medical burdens on the body, and their improper selection or misuse can place individuals at significant health risk, their use is regulated by OSHA and UVA. Respirators are not all the same nor do they provide universal protection against all inhalation hazards. Where needed, only NIOSH-certified respirators may be used at UVA. Individuals considering the use of a respirator must contact EHS to review the intended application and assist in the proper selection, training, fit testing, and maintenance of respirators. Those individuals will also need medical clearance in advance from their UVA healthcare provider.

Personal Protective Equipment Selection Guidelines

Material or Activity	Potential Exposures	Personal Protective Equipment
Basic entry into laboratories with hazardous materials or operations	• Chemical contamination • Splash or flying object to eyes	• Standard clothing and attire: o Long-hair, beards, and loose clothing and hanging jewelry secured as needed o Non-absorbent, closed toe shoes o Clothing that covers the legs • Other PPE will be driven by laboratory-specific policy

Material or Activity	Potential Exposures	Personal Protective Equipment
Handling hazardous chemicals (< 1 Liter)	• Chemical contamination • Splash or flying object to eyes	Basic entry PPE plus: • Safety glasses with sideshields • Laboratory coat • Gloves - disposable nitrile exam gloves for incidental contact. Consult EHS training *Glove Selection* for additional advice on high hazard materials
Handling hazardous chemicals (> 1 Liter)	• Chemical contamination • Chemical burns from corrosive materials • Splash or flying object to eyes and face	Basic entry PPE plus: • Enclosing safety goggles, or faceshield for high-risk splash potential • Laboratory coat • Rubber splash apron for corrosives • Gloves, disposable nitrile, or forearm length utility gloves worn over nitrile exam gloves for potential long term exposure or immersion. Consult EHS training *Glove Selection* for additional advice
Handling hot objects or working with open flames	• Thermal burns • Flying object to eyes and face	Basic entry PPE plus: • Laboratory coat (flame resistant for open flame work > than Bunsen burner scale) • Gloves – heat resistant • Safety glasses with sideshields
Working with pyrophoric or water-reactive compounds	• Chemical contamination • Splash, flames, and burns to body, face, and eyes	Basic entry PPE plus: • Safety Goggles (glove box) • Faceshield (fume hood work) • Flame-resistant laboratory coat • Gloves – flame resistant worn over disposable nitrile exam gloves. Consult EHS training *Glove Selection* for additional advice • Perform work in chemical fume hood or glove box as appropriate. • Prior to use: o Complete EHS training *Handling Organolithium and Related Agents* o Obtain hands-on training from supervisory personnel
Working with highly reactive or explosive compounds	• Chemical contamination • Physical injuries from flying objects and fragments	Basic entry PPE plus: • Safety glasses • Faceshield • Flame resistant laboratory coat • Gloves – forearm length utility gloves worn over nitrile exam gloves. Consult EHS training *Glove Selection* for additional advice • Perform work in chemical fume hood, glove box, or behind shield, as appropriate
Working with deep vacuum or high-pressure equipment	• Chemical contamination • Physical injuries from flying objects and fragments	Basic entry PPE plus: • Safety glasses • Faceshield

Material or Activity	Potential Exposures	Personal Protective Equipment
		• Laboratory coat • Gloves – forearm length utility gloves worn over nitrile exam gloves. Consult EHS training *Glove Selection* for additional advice • Perform work behind shield as appropriate
Working with cryogenic liquids	• Frozen tissues • Splashes to body, face, and eyes	Basic entry PPE plus: • Safety goggles or Faceshield • Laboratory coat • Gloves – insulated, forearm length or longer • Potential asphyxiation hazards if working in small, enclosed space without ventilation. Consult with EHS if you have questions about appropriate ventilation.
Performing small volume chemical spill clean-up	• Chemical contamination	Basic entry PPE plus: • Safety goggles • Laboratory coat • Gloves – double nitrile exam gloves or utility grade forearm length gloves over exam gloves. Consult EHS.
Working with or near high noise sources	• Hearing damage	Basic entry PPE plus: • Hearing protection devices – ear muffs or plugs. Consult EHS for assistance in monitoring the noise source(s) and selecting PPE.
Working with intense sources of visible or non-visible light, lasers, high electric or magnetic field equipment, ionizing radiation sources	• Physical injuries	• Consult EHS

Safe Management of Chemicals

This section provides general guidance for safely managing hazardous chemicals in the laboratory. Additional information is provided during laboratory chemical safety training; more specific techniques and practices are best learned from colleagues and laboratory supervisory personnel.

Chemical Ordering and Receipt

- Avoid duplication by reviewing existing chemical stocks before placing new orders. If a reagent is still needed, order only as much as needed since "volume discounts" are a false economy - larger quantities mean larger spills and higher disposal costs.
- UVA limits individual chemical containers to a maximum capacity of 4 Liters or 1 gallon. The Virginia State Fire Marshal does not permit the storage and use of flammable liquids in 5 gallon cans.
- Order chemicals from reputable, university-approved vendors using standard departmental delivery and receiving instructions.
- Where a choice is available, order chemicals in safety-coated or shatter-resistant containers, especially corrosive and reactive materials.
- Ensure your laboratory has an appropriate place to store and use new chemicals. For example, toxic volatile liquids require a chemical fume hood, while compressed toxic or corrosive gases generally require a dedicated ventilated gas cabinet. Consult EHS if you have questions about the safety infrastructure needed for a new chemical.
- The ordering laboratory is responsible for any special permits or licenses required for a chemical.
- Have chemicals delivered directly to the laboratory or departmental receiving location. Upon receipt:
    - Verify the container and label are intact,
    - Confirm that the contents match the original order,
    - Date-label reactive and unstable materials, and consider date-labeling all containers,
    - Safely move the container to its proper storage location and update applicable inventory records.

Chemical Transport

- When transporting chemical containers outside of the laboratory, use a secondary container such as a chemical bottle tote, covered bucket, or a tray.
- When moving chemicals on a cart, be sure to secure the load or use a cart with raised edges. Wheels should be large enough to roll over uneven floor surfaces and elevator door gaps.
- Use extra care when transporting chemicals in elevators since these locations have limited ventilation and are difficult to exit quickly in the event of a spill.

- Contact EHS for assistance if you need to:
    - Transport large quantities of chemicals elsewhere indoors,
    - Move or transport chemicals outdoors, including liquid nitrogen Dewar vessels,
    - Ship any chemicals or research specimens off-Grounds.

Chemical Storage

- Keep quantities of chemicals to the minimum needed.
- Maintain an inventory for Particularly Hazardous Substances, and consider keeping one for all other chemicals to reduce wasteful duplication.
- Avoid simple alphabetical storage of chemicals for all but the most innocuous compounds. Instead, segregate and store chemicals by their hazards using a classification system such as the one shown in the table at the end of this section.
- Store concentrated acids and bases separately in corrosion-resistant trays, at or near floor level in cabinets or under fume hoods. For aggregate quantities greater than a few Liters, use specially constructed corrosion-resistant acid/base storage cabinets.
- Keep flammable liquids in storage devices listed or approved by Factory Mutual or the National Fire Protection Association. Flammable storage cabinets must have self-closing doors and be prominently posted. Cabinet vents must be capped closed or, if connected to building exhaust, provided with a flame arrestor. Refrigerators and freezers used to store flammable liquids below room temperature must also be listed or approved for such use – never store flammable materials in an ordinary refrigerator or freezer.
- Date-labeling is recommended for all chemicals, but especially for unstable materials and those that can form reactive / explosive secondary products over time such as peroxides and shock-sensitive salts, e.g., ethers, other peroxide-forming chemicals, picric acid, perchloric acid.
- Periodically inspect chemical storage areas for out-of-date or expired materials and for any containers with damages such as bulging or deformation exteriors, broken caps or lids, discoloration, or unexpected precipitates or crusts. Consult EHS for assistance before moving or repackaging.

Newly Synthesized and Novel Chemicals

The hazards of newly synthesized and novel chemical compounds are rarely known, even when they are similar in structure to other chemicals. It is prudent to treat these kinds of materials as hazardous until determined otherwise. If your laboratory synthesizes or otherwise produces such materials for sale, distribution, or other use outside of UVA, contact EHS since these compounds will require additional assessment, labeling, and hazard documentation prior to shipping.

Compressed Gases

- Secure compressed gas cylinders at all times in the upright position, and protected from falls by using straps, chains, or safety stands designed for that purpose.

- Store cylinders in cool, dry, well-ventilated areas away from heat, flammable liquids, and corrosive materials. Store cylinders by gas type, separating oxidizing gases from flammable ones. Keep valve cover caps on until a cylinder is used.
- Move compressed gas cylinders on cylinder transport carts with straps or chains in place and valve cover caps secured.
- Ensure that cylinders are prominently posted / labeled as to their contents, and also tagged as "Full", "In Use", or "Empty" as appropriate.
- Avoid lecture bottles where possible since they are expensive to dispose of - instead, select the smallest possible refillable style of cylinder.
- Follow supplier's technical bulletins for proper regulator selection, along with any other gauges, valves, hoses, or manifolds. In general, two-stage regulators should be used as they provide immediate indications of the pressure of cylinder contents and enable precision control of the outlet delivery pressure.
- Store regulators in a clean, dry location when not in use. Inspect them before and after use. Never force valve or regulator connections – always hand thread them to start. Test all connections for leaks with soapy water (some less common gases may require a different leak test solution – consult EHS).
- Lubricants and greases should never be used on regulators or gas cylinder fittings. Refer to supplier technical bulletins for when to use Teflon tape, washers, or special consumable seals.
- Compressed hydrogen is lighter than air and highly flammable, with a very wide range of explosive concentrations. The Virginia fire code greatly limits the quantity of flammable compressed gases that can be stored on elevated floors or the basement of buildings. If hydrogen is needed regularly and in significant quantity, consider a hydrogen generator instead of compressed gas cylinders. These devices work by catalyzing water, and can produce ultra-high purity hydrogen gas at pressures sufficient for most laboratory applications. When turned off, the only quantity of hydrogen gas remaining is the residual volume inside piping or tubing, essentially eliminating the fire hazards from this gas. The same kind of technology can be used to produce high purity oxygen. Contact EHS for additional information.
- Most inert gases are permitted in UVA laboratories without special ventilation, but compressed toxic, reactive, and most flammable gases require storage inside a chemical fume hood or a dedicated exhausted gas cabinet. Certain gas storage and delivery systems also require active leak detection and alarms.
- Additional information is available from the EHS on-line module, *Compressed Gas Cylinder and Regulator Safety.*

Cryogenic Liquids and Dry Ice

- Cryogenic liquids are supplied in special insulated ("Dewar") vessels with pressure relief fittings. To the extent possible, avoid damp areas since moisture can result in excess ice

formation around the relief valve. Periodically inspect cryogenic liquid vessels wherever they are stored.

- Store cryogens and dry ice in well-ventilated areas since they are continuously "boiling off" or sublimating to a gaseous state. Do not store cryogenic liquid or dry ice in cold rooms, as they are not ventilated spaces.
- Cryogenic liquids and dry ice can easily damage laboratory countertops and sinks, and floor tiles; avoid prolonged contact with any material not designed for extreme low temperatures. Never dispose of dry ice in lab sinks; instead, allow dry ice to sublimate in a loose fitting cooler in a well-ventilated space.
- Avoid transporting cryogen tanks (i.e., 240 L tanks) in passenger elevators. Use service elevators when available, and do not ride with the tank in the elevator. Use a "buddy system" to intercept passengers if you must transport up or down several floors.
- Upgrade personal protective equipment with a faceshield (over safety glasses) and heavy insulated forearm-length gloves when dispensing cryogenic liquids.
- Oxygen deficiency detection, alarms, and control systems may be needed in enclosed rooms where appreciable quantities of cryogenic liquid are stored and in such places where filling or dispensing operations occur. Contact EHS for additional information.

Chemical Fume Hoods and Other Local Exhaust Ventilation Devices

- Use a chemical fume hood, snorkel, or other local exhaust ventilation device for procedures that release toxic vapors, fumes, mists, or dusts. Ensure that the device has been certified and is operating properly. Notify laboratory supervisory personnel, Facilities Management, or EHS of any problems.
- Chemical fume hoods: Follow posted safe use guidelines. Place equipment and reagents inside the hood and lower the sash to the marked height. Work at least 6 inches inside of the hood sash, preferably even deeper. Raise large equipment on test tube racks to improve airflow. Avoid using chemical fume hoods for storage by limiting their use to those operations and procedures that require local exhaust. Stop work immediately if you detect any odors of the chemicals being used inside; notify others in the laboratory, post a warning sign on the sash, and contact EHS and Facilities Management as soon as possible for repair.
- Special note on perchloric acid: The use of perchloric acid can result in the accumulation of explosive perchlorate crystals on chemical fume hood surfaces and inside ductwork. Work that involves heating or evaporating concentrated perchloric acid must be performed in a special Perchloric Acid Fume Hood. These devices have self-contained water rinsing and wash-down features to minimize the formation and accumulation of reactive crystals. Dedicated Perchloric Acid Fume Hoods already exist on Grounds - contact EHS for assistance.

Chemical Storage Guidelines

Chemical Groups	Storage Guidelines
General, Non-Hazardous Chemicals Acetates, borates, carbonates, chlorides, glycols, halides, nitrides, phosphates, phosphides, polysulfides, silicates, sulfates, sulfides, sulfoxides, thiosulfates	*Non-hazardous salts and buffers may be stored alphabetically.*
Volatile Liquids: **Flammable:** Alcohols, alkanes, amides, amines, aromatic hydrocarbons, esters, ethers, ketones **Non-Flammable:** Halogenated hydrocarbons (e.g., Chloroform, carbon tetrachloride, methylene chloride	*Store in cabinet or near fume hood for convenience. Separate flammable from non-flammable liquids and limit volumes to the smallest amounts needed. Flammable liquids must be stored in a rated cabinet or spark-proof refrigerator / freezer.*
Water and Air Reactive Compounds: Calcium, sodium, potassium, lithium, phosphorus pentoxide, pyrophorics such as butyl-lithium.	*These kinds of chemicals are usually shipped under mineral oil or an inert atmosphere. Store in original container unless supplier advises otherwise.*
Corrosives: **Acids:** Mineral acids (e.g., hydrochloric), organic acids (e.g., acetic), per-acids **Bases:** Hydroxides, organic bases **Other:** Cresols, phenols, anhydrides	*Store below eye-level in dedicated area (e.g., poly-ethylene trays under sink or fume hood) or corrosive cabinet. Store oxidizing acids (e.g., perchloric, nitric) separately. Note that concentrated acetic acid is flammable.*
Oxidizers Amides, bromates, chlorates, chlorites, chromates, hypochlorites, hydroperoxides, manganates, nitrates, nitrites, perchlorates, permanganates, peroxides	*Store oxidizers separately. Store peroxidizable chemicals below room temperature but above freezing. Inspect caps for presence of potentially shock-sensitive crystals before opening.*
Compressed Gases: Air, noble gases (e.g., argon, neon), chlorine, helium, hydrogen, nitrogen, oxygen	*Secure cylinders. Keep valve caps on when not in active use. Consider gas generators as alternative to compressed H_2 or O_2. Toxic, corrosive, and flammable gases may require storage in a chemical fume hood or dedicated gas cabinet.*
Cryogenic Liquids: Nitrogen, helium	*Store vessels in dry, cool, well-ventilated locations. Consult EHS for information and options for oxygen monitoring.*
Chemicals Requiring Refrigeration: *Various*	*Non-flammable, non-oxidizing chemicals can be stored in ordinary refrigerators / freezers but flammable and oxidizing chemicals must be stored in an explosion-proof refrigerator or freezer.*
Select Carcinogens, Reproductive Toxins, and Highly Toxic Chemicals: Consult container labels, SDSs, or EHS.	*Store these materials in a separate area or within a secondary container to facilitate tracking. Ensure that only authorized individuals can access them.*
Controlled Substances: Schedule I – V drugs under the US DEA, plus VBP Schedule VI drugs	*Keep an inventory and store under lock and key; Schedules I and II require additional security. Consult Center for Comparative Medicine and Office of Animal Welfare for more information.*
DHS Chemicals of Interest: Specific chemicals with potential for harm upon accidental or purposeful release, theft, or sabotage.	*Store according to hazardous properties and ensure only authorized individuals in the laboratory can access them. Consult EHS for more information.*
Tax-Free Ethanol: 200 proof ethyl alcohol	*Limit access to authorized laboratory personnel by keeping tax-free alcohol in a locked flammable storage cabinet or in an unlocked cabinet within a room that is locked when unattended.*

Good Work Practices

This section provides general guidance on work practices and procedures in the laboratory. Additional information is provided during chemical safety and waste training, and from laboratory supervisory personnel.

Be Prepared

- Identify the hazards of reagents and equipment in advance by reviewing Safety Data Sheets and written procedures.
- Know where the closest emergency equipment is located, including emergency eyewashes and showers, landline phone, and first aid and spill supplies. For work with pyrophoric chemicals and other air / water reactive materials, keep an appropriate portable fire extinguisher ready for use nearby.
- Follow standard operating procedures, posted instructions, curriculum, or supplier / manufacturer guidelines, and document experiments in a laboratory notebook.

Attire, Personal Protective Equipment, Habits, and Behavior

- Wear closed-toe, slip-resistant, non-absorbent footwear and clothing that covers the legs in the laboratory. Confine or restrain long hanging hair and beards, loose clothing or scarves, and any dangling jewelry.
- Put on basic personal protective equipment required by individual laboratory protocol, typically safety glasses with side shields and a laboratory coat; add gloves where chemical contact may occur. Do not wear contact lenses unless splash- and vapor-proof goggles are worn. Remove personal protective equipment and wash hands before leaving the laboratory.
- Horseplay and practical jokes have no place in the laboratory.
- Never purposefully smell, taste, or touch chemicals.
- Eating, drinking, smoking, vaping, chewing gum, and applying cosmetics or lip balm is prohibited in the laboratory and all other areas where chemicals are stored or used.

Working Alone and Unattended Operations

- Avoid working alone. If solo work is absolutely necessary, review in advance with laboratory supervisory personnel. For work with high hazard materials, put additional safeguards in place, including pre- and post-work notifications to supervisory personnel and colleagues. Consult EHS for additional information and advice.
- Unattended operations are also discouraged, especially those that are high hazard. Review high hazard procedures in advance with laboratory supervisory personnel. Where experiments must proceed unattended, place a note next to the area or apparatus and on the laboratory door with the following minimum information: the chemicals involved, utilities being used (e.g., chilled water, vacuum, electricity or heat), your name,

date and time (start and end of experiment), and a contact number where you can be reached in case of an emergency.

Basic Laboratory Procedures

- Keep floors, benchtops, and chemical fume hoods clear, uncluttered, and clean.
- Use equipment and reagents for their intended purpose only, and seek advice for new procedures.
- Use mechanical devices when aspirating chemicals - never mouth pipette. Avoid traditional syringes and needles, glass Pasteur pipettes, capillary tubes, and other Sharps unless absolutely necessary. Where possible, substitute blunt cannula devices and precision mechanical pipettors.
- When diluting concentrated acids, *always add acid to water* – not the other way around. Work behind the sash of a chemical fume hood or a portable splash shield, consider the need for an ice bath, and proceed slowly. Upgrade personal protective equipment to include a faceshield and arm protection using disposal coated "sleeves."
- Disposable labware has largely supplanted traditional glass products, but glass is still in wide use for tubing, reaction vessels, distillation, and other operations. Carefully handle and store glassware to avoid injury. Inspect before and after use, and discard damaged pieces. Shield or tape-wrap Dewar flasks and other glass apparatus that is either under vacuum or elevated pressure. Avoid chromic acid for glassware cleaning.
- Procedures that may release toxic vapors, fumes, mists, or aerosols should be performed in a chemical fume hood or other local exhaust ventilation device.
- Original labels must remain on chemical containers. However, glassware and other vessels used for handling, transferring, or mixing chemicals need not be labeled if they will remain in full control of the same person and are used only temporarily and immediately (i.e., not left unattended). All other secondary containers (e.g., squeeze bottles, laboratory-prepared stock solutions) must be labeled with their name or commonly recognized acronym or abbreviation, e.g., 70% EtOH, 1 M NaCl, Luria Broth.
- Bunsen burners are allowed in laboratories provided the immediate areas around them are kept clear of combustible and flammable materials. Open flame work beyond the scale of a Bunsen burner must be reviewed and approved in advance by EHS.
- Distillation and other hot operations should be performed with a heating mantle or hot plate only. For routine purification needs, cold solvent filtration systems are greatly preferred over hot distillation; contact EHS for advice.
- Place laboratory balances or scales in low pedestrian traffic areas of the laboratory, away from doors and overhead supply air grilles to minimize air disturbances.
- Promptly notify laboratory supervisory personnel of any maintenance problems or equipment malfunctions. Until repaired, tag equipment as "out of service" and advise maintenance / service personnel of any hazards they may encounter.

Additional Requirements for Particularly Hazardous Substances

When working with Particularly Hazardous Substances or other high hazard or regulated chemicals, laboratories are advised to:

- Maintain an inventory of these chemicals and restrict access to authorized persons.
- Seek formal review and approval from laboratory supervisory personnel for new work or scale-ups. Conduct a "dry run" as appropriate and revise experimental procedures accordingly. Seek help in the event of any problems or unusual conditions.
- Establish one or more Designated Areas for the handling and use of these chemicals. The Designated Area may be as small as a portion of a laboratory bench, the interior of a chemical fume hood, or as large as the entire laboratory. Select an area that is appropriate to the properties of the chemicals being used. Post Designated Areas with labels or signage as follows:

WARNING
DESIGNATED AREA
For Use of Select Carcinogens, Reproductive Toxins, and Acute Toxins

- Provide containment appropriate to the chemical and task such as an absorbent bench coating or covering, non-absorbent tray, or a device with inherent spill containment such as the interior of a chemical fume hood.
- Weigh dry powders in a HEPA filtered weigh station enclosure or inside a chemical fume hood with a shield to minimize air currents. Preparing concentrated stock solutions is preferred to repeated dry powder handling if the resulting solution is stable and has good storage characteristics. Alternatively, where possible, purchase highly toxic dry powder reagents in pre-weighed vials with rubber septa to eliminate open air powder handling entirely.
- Perform any inactivation, neutralization, or other step(s) designed to render a hazardous chemical into a less or non-hazardous state before completing the experimental procedure. Review these protocols in advance with EHS.

Emergency Preparedness and Response

In the event of a serious or life threatening medical, fire, police, outdoor hazardous materials spill, or other emergency, dial 911 from any phone. Provide the dispatcher with as much information as possible, the specific location of the emergency, and stay safely nearby to help direct emergency responders to the scene and answer any questions.

Emergency Preparedness

- Prepare for laboratory accidents by completing required safety training and learning as much as possible about the hazards in your laboratory and their control.
- Be sure landline phones are in working order and posted with UVA emergency contact information.
- Consult the UVA Office of Emergency Preparedness website for information on emergency procedures and your building's evacuation site.
- Ensure that spill response and personal protective equipment supplies are available.
- Keep aisles and exits clear, and maintain ready access to emergency eyewashes, showers, and fire extinguishers.
- For work with hazardous materials:
    - Use the buddy system, and preferably work only during regular business hours.
    - For the small number of compounds with special first aid procedures or an antidote (e.g., hydrofluoric acid or hydrogen fluoride, cyanides), review in advance with EHS and your UVA healthcare provider.
- Fires involving pyrophoric compounds and reactive metals are not easily extinguished with standard fire extinguishers. For these materials, a bucket of dry sand or a special Class D fire extinguisher are usually needed. Contact EHS and Facilities Management to ensure your laboratory has the right extinguisher(s).
- If urgent spill response is needed, call EHS at 434-982-4911. If there is another or an additional type of emergency, call 911 immediately; only after urgent needs are met, report to EHS. Report any accidents, safety concerns, hazardous situations, or "near miss" events using EHS's on-line form (www.ehs.virginia.edu).

Test Emergency Eyewashes

Laboratories are responsible for testing stand-alone eyewashes inside their laboratories to ensure they are ready for use. On at least a monthly basis:

- Visually examine eyewashes for any leaks, corrosion, or defects; contact Facilities Management to correct any problems,
- Activate and flush each unit for several minutes,
- Verify that eyewashes turn on with a single motion, remain on, and provide two streams of water,

- Record date and name of tester on the test record tag.

Eyewash test record tags are distributed by EHS during laboratory inspections and audits; contact EHS if you need more.

Fire or Smoke Conditions

a. Pull the nearest fire alarm and tell others nearby. Follow-up by dialing 911 from any phone, and give as much information as possible.
b. Safely stop what you are doing, turn off electrical equipment, and shut off any open flames or sources of gas.
c. Close doors behind you to slow the spread of smoke and flames.
d. Go to the nearest exit or stairway – do not use an elevator. If smoke levels are heavy, stay low to the floor. Use an alternate exit if anything blocks your route.
e. Leave the building and assemble at a safe distance nearby. Identify yourself to emergency responders and share information about the incident with them.

Portable Fire Extinguishers

Individuals knowledgeable in the use of portable fire extinguishers may consider using one after emergency assistance has been summoned. Always keep your back towards the exit door or pathway, and immediately leave the area if the fire does not go out. Use the acronym PASS to help remember the four steps to effective fire extinguisher use:

- **Pull** the safety ring / pin at the top of the unit,
- **Aim** the hose or discharge funnel at the base of the fire,
- **Squeeze** the handle of the extinguisher to discharge it at the fire, and
- **Sweep** from side to side, aiming at the base of the fire. Continue spraying until the fire is out or the extinguisher is empty.

EHS's Fire Safety group provides in-person fire extinguisher training. Consider having your laboratory participate in one - call EHS to schedule.

Minor Chemical Spills (Low Hazard, < 1 Liter)

a. Trained laboratory personnel can clean-up most minor spills on their own. But do not proceed if you have any concerns about your ability to safely clean the spill – contact EHS at (434) 982-4911.
b. Tell others in the area and restrict access to the spill location. If anyone has already left the area, examine the potential for contamination to have spread.
c. Identify the material(s) involved, quantity, and specific location. Review the Safety Data Sheet or contact EHS for additional information about the chemical. Re-assess the situation, and summon emergency assistance if needed.

d. Wear standard laboratory personal protective equipment appropriate for the spill. If you believe respiratory protection is needed, the incident is not a minor one - contact EHS for assistance.
e. In general, minimize air disturbances and drafts for dry powder spills, but increase ventilation by opening nearby chemical fume hood(s) for most volatile liquids.
f. Confine liquid spills with absorbent materials to minimize spread.
g. Use the appropriate spill kit to absorb or neutralize the material, and work from the perimeter inwards. Collect residue with a small non-reactive shovel, scoop, dust pan, or piece of cardboard, place in heavy plastic bag or other compatible container, label contents as waste, and arrange for pick-up by EHS.
h. Clean the spill area with soap and water. Contact EHS if you need additional assistance.
i. In the event any property or equipment was damaged, contact the UVA Office of Property and Liability Risk Management.
j. Review the incident with colleagues and institute any measures that could prevent a recurrence.

Larger or More Hazardous Chemical Spills

a. Summon emergency assistance by dialing 911 from any phone for situations that threaten life or property and give as much information as possible. Indicate that the incident involves a large or hazardous chemical spill.
b. For less serious spills, notify laboratory supervisory personnel and EHS at (434) 982-4911. After regular business hours, a voice recording will provide guidance and allow you to connect to the University Emergency Operator who will then notify the appropriate EHS staff member on-call for further assistance.
c. Tell others in the area and restrict access to the spill location. If anyone has already left the area, examine the potential for contamination to have spread. Consider whether or not to evacuate a larger area.
d. Identify the materials involved, quantity, and specific location of the spill.
e. Attend to any injured or contaminated persons and remove them from exposure. In case of personal contamination, remove affected clothing and rinse contaminated skin with water for at least 15 minutes.
f. If safe to do so, turn off nearby electrical equipment, shut off any open flames or sources of gas, and turn off any other equipment or operation that could pose a hazard if left unattended.
g. In general, minimize air disturbances and drafts for dry powder spills, but increase ventilation by opening nearby chemical fume hood(s) for most volatile liquids.
h. Close room door(s) and safely wait nearby for emergency responders to arrive.
i. Provide responders with as much information about the incident as possible, and assist them as requested.

j. In the event any property or equipment was damaged, contact the UVA Office of Property and Liability Risk Management.
k. Participate in the post-incident review and institute any measures that could prevent a recurrence.

Metallic or Elemental Mercury Spills

While not nearly as toxic as organic forms, elemental mercury spills are difficult to clean-up effectively without special equipment and instrumentation. Despite the high density of liquid mercury, spilled droplets tend to shatter and spread widely. Once dispersed, fine mercury droplets are tenaciously "sticky" and resist common collection techniques. Unless your laboratory has been provided with special training, equipment, and approval from EHS, do not attempt to clean-up a mercury spill. Instead:

a. Tell others in the area and restrict access to the spill location. If anyone has already left the area, examine the potential for contamination to have spread. For spills involving more mercury than is contained in a typical laboratory thermometer, evacuate the room and close the door.
b. Notify laboratory supervisory personnel and EHS at (434) 982-4911. After regular business hours, the voice recording will allow you to connect to the University Emergency Operator who will then notify the appropriate EHS staff member on-call for further assistance. Give as much information as possible. Be sure to indicate that the incident involves mercury. For mercury spills after hours, you may be asked to vacate and secure the area for response the following morning.
c. Await safely nearby for EHS responders to arrive.
d. Provide responders with as much information about the incident as possible, and assist them as requested.

First Aid for Hazardous Materials Exposures

b. The procedures below provide basic guidance for responding to most hazardous materials exposures, including several chemicals that carry special first aid steps. Additional information is available from EHS. Where possible, secure or save the container(s) involved to help ensure accurate chemical identification, and provide a copy of the Safety Data Sheet as soon as possible to emergency responders or the hospital. EHS can also assist with any urgent chemical information needs.
c.

Clothing on Fire / Burning Chemical

a. Extinguish burning clothing by using the drop-and-roll technique or dousing the victim with water using the nearest emergency shower, retractable eyewash, or sink hose - but never spray anyone with a fire extinguisher.

b. Remove contaminated clothing if possible to do so without damaging skin. If uncertain, leave clothing in place and continue rinsing with water.
c. Summon emergency assistance by dialing 911 from any phone, and give as much information as possible.
d. Cool affected area with ice packs or cold water.
e. Help prevent shock by having the victim sit / lie down, and remain with them until emergency responders arrive.
d.

Chemical Splash to the Eye(s)

a. Flush the eyes(s) at the nearest emergency eyewash, forcibly holding the eyelids open to ensure effective rinsing. Continue rinsing for at least 15 minutes.
b. Follow with prompt treatment or triage by medical personnel (See Medical Services)
    a. Victim or person assisting victim may call healthcare provider prior to arrival.
c. If the situation requires emergency assistance, dial 911 from any phone, and give as much information as possible. Remain with the victim until emergency responders arrive.

Chemical Spills and Splashes to the Body

a. Remove any contaminated clothing or personal protective equipment.
b. Immediately rinse the affected body area(s) with water for at least 15 minutes, using the nearest emergency shower, retractable eyewash, or sink hose.
c. Follow with prompt treatment or triage by medical personnel (see Medical Services)
    a. Victim or person assisting may call healthcare provider prior to arrival.
d. If the situation requires emergency assistance, dial 911 from any phone, and give as much information as possible. Remain with the victim until emergency responders arrive.

Ingestion of Chemicals

a. Summon emergency assistance by dialing 911 from any phone, and give as much information as possible.
b. Do not induce vomiting or give water or other liquids unless instructed to do so by emergency responders.
c. Remain with the victim until emergency responders arrive.

Inhalation of Chemicals

a. Summon emergency assistance by dialing 911 from any phone, and give as much information as possible.
b. Remove the exposed person to clean air and treat for possible shock by having them sit or lie down.
c. Do not return to the incident scene if you suspect that a dangerous condition persists.
d. Remain with the victim until emergency responders arrive.

Cyanides

Immediately summon emergency medical assistance, indicating that the exposure involved cyanide. Follow the steps outlined above for chemical exposures, but in the event of an inhalation or ingestion exposure, do not provide mouth-to-mouth resuscitation as this may cause serious exposure to the rescuer. Cyanide antidote kits are available at local hospital emergency departments; for laboratories that use or generate hazardous quantities of cyanide, review antidote access with your UVA Healthcare provider in advance.

Hydrogen Fluoride and Hydrofluoric Acid

Concentrated forms of these compounds are readily perceived by a burning sensation, but more dilute forms may be imperceptible for hours, with the time delay potentially leading to insidious and difficult-to-treat burns. Initiate first aid as follows:

Skin Exposure to HF

a. Remove any contaminated clothing or personal protective equipment, and immediately flood the affected body area(s) with water for at least 15 minutes, using the nearest emergency shower, retractable eyewash, or sink hose. Limit to 5 minutes if calcium gluconate gel is available.
b. Wearing gloves, gently rub calcium gluconate ointment onto the affected area.
c. Proceed immediately to the Emergency Department (ED) for medical treatment.
d. If the situation requires emergency assistance to get to the ED, dial 911 from any phone, and give as much information as possible. Continue to apply calcium gluconate gel until emergency responders arrive.
e. Remain with the victim until emergency responders arrive.

Eye Exposures to HF

a. Immediately flush eyes for at least 15 minutes with water. Hold the eyelids open and away from the eye during irrigation to allow thorough flushing of the eyes. Use the nearest emergency eyewash or sink hose.
b. Proceed immediately to the Emergency Department (ED) for medical treatment.
c. If the situation requires emergency assistance to get to the ED, dial 911 from any phone, and give as much information as possible.
d. Remain with the victim until emergency responders arrive.

Inhalation Exposures to HF

a. Move inhalation exposure victim to clean air, and attend to any other body or clothing contact. Take appropriate precautions to protect rescuers from any potential contamination.
b. Summon emergency assistance by dialing 911 from any phone, and give as much information as possible.
c. Remain with the victim until emergency responders arrive.

Exposure Assessments

Based upon published literature and previous exposure monitoring by EHS, there is no reason to believe individuals working or studying in UVA laboratories are routinely over-exposed to hazardous chemicals. This is largely due to the small quantities of chemicals handled in most laboratories and the use of personal protective equipment and engineering controls such as chemical fume hoods.

In the event of an actual or suspected chemical over-exposure, the exposed individual or the individual's supervisor must contact EHS to perform an exposure assessment. The assessment will include an evaluation of the chemicals involved, specific procedures, and the control measures in use. It may also include air monitoring or surface contamination testing, as appropriate, to characterize the potential exposure and identify any additional control measures needed. These steps will also be performed in the event of chemical emergencies or reports of medical signs or symptoms associated with over-exposure.

Where monitoring is warranted, it will be performed by trained professional staff using standard sampling and analytical methods, and any laboratory testing will be performed by an AIHA-accredited laboratory. Results, conclusions, and recommendations from the exposure assessment will be shared with the requesting individual(s), their UVA healthcare provider, and laboratory supervisory personnel, as appropriate. Monitoring records will be maintained by EHS according to OSHA's recordkeeping requirements.

Anyone with questions about potential chemical over-exposure or monitoring in the laboratory should contact EHS.

Medical Services

In the event that a serious accident or chemical exposure requires emergency medical services, treatment will be coordinated on-scene by the first responders.

For non-emergency medical assistance such as minor first aid or questions about laboratory-related health issues, contact the appropriate UVA occupational health provider as follows:

If You Are:	UVA Academic	UVA Medical Center	UVA Wise
Faculty, staff, students paid through University Payroll	UVA-WorkMed 1910 Arlington Blvd. (434) 243-0075	UVA Employee Health 1222 Jefferson Park Ave. (434) 924-2013	UVA Student and Employee Health Clinic Lower Level Cantrell Hall (276) 376-3475
All other students	Student Health 400 Brandon Ave. (434) 924-5362 (434) 297-4261 after hrs	Student Health 400 Brandon Ave. (434) 924-5362 (434) 297-4261 after hrs	
Visiting scientists and scholars, interns, volunteers	UVA-WorkMed 1910 Arlington Blvd. (434) 243-0075	UVA Employee Health 1222 Jefferson Park Ave. (434) 924-2013	

Individuals using hazardous chemicals at UVA should also obtain medical consultation if they:

- Develop any signs or symptoms associated with hazardous chemical exposure,
- Are exposed to a hazardous chemical above the OSHA action level or permissible exposure limit, or
- Experience an event such as a spill, leak, explosion, or other occurrence with a potential for exposure to a hazardous chemical.

The individual must report their exposure, or potential exposure, to the PI or laboratory supervisor. The PI or laboratory supervisor shall provide the following information to the UVA healthcare provider and the EHS Occupational Health Group (434-982-4911):

- Identity of the hazardous chemical(s) to which the individual may have been exposed, preferably along with copies of Safety Data Sheets,
- Description of the conditions and activities that may have resulted in potential exposure, including any quantitative monitoring data, and
- Description of the signs / symptoms experienced, if any.

Upon completion of the initial consultation(s) and any medically-indicated follow-up examination(s), the healthcare provider must provide a written opinion that addresses, at a minimum, the following:

- Any recommendations for further medical follow-up,
- Results of examinations and tests,
- Any medical condition revealed that might place the individual at increased risk as a result, but not revealing any findings or diagnoses unrelated to the laboratory exposure.

Individuals and/or the healthcare provider shall review this information confidentially with EHS and the laboratory supervisor to ensure that an incident investigation and assessment (see Exposure Assessments) leads to necessary corrective actions and implementation to control further chemical exposures.

Individuals with underlying health conditions that could be negatively impacted by the use of hazardous chemicals or materials in a laboratory, including those contemplating pregnancy or who are already pregnant, are also encouraged to review their specific health circumstances and laboratory activities with the appropriate UVA healthcare provider.

Medical consultations and any follow-up examinations will be performed by or under the direct supervision of a licensed physician, free-of-charge, with no loss in pay, and at a reasonable time and location.

Hazardous Waste Management

In Virginia, hazardous chemical waste is regulated by the Department of Environmental Quality, following rules established by the U.S. Environmental Protection Agency. Everyone who generates hazardous waste at UVA shares responsibilities for its proper management and disposal. Often called *cradle to grave*, these responsibilities begin at the time a chemical is declared unwanted and becomes a waste, through multiple handling and transportation steps both on- and off-site, and ultimately to final disposal. Hazardous waste management rules are complex and carry significant penalties for violation.

EHS manages the overall UVA hazardous waste program, including performing periodic waste inspections and providing information, containers, special labels, and waste collection and disposal services all free-of-charge.[1]

The following provides a brief introduction to hazardous waste management practices at UVA. More detailed information is available from EHS on our website or by contacting us directly.

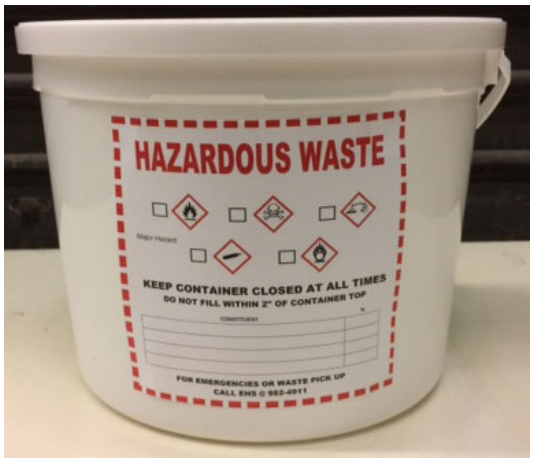
- Complete required chemical safety and hazardous waste training and learn about your laboratory's specific practices.
- Review experimental procedures to determine if any chemicals can be eliminated, substituted with less hazardous materials, or used in smaller quantities.
- Order chemicals in the smallest quantities needed in order to reduce the amount of waste they generate.
- Consult EHS about any new, unusual, or high-volume waste streams in your laboratory.
- Sink drain disposal is limited to dilute, non-hazardous aqueous and water miscible materials, typically buffer solutions, disinfected tissue and cell culture media, and glassware and container rinse waters of non-toxic chemicals. Consult EHS if you have any questions.
- Avoid mixing different chemical waste streams together - instead collect them by their hazardous properties. If in doubt, segregate them and contact EHS for additional guidance (see EHS's waste segregation guidelines on our website).
- Most empty chemical containers are not recyclable at UVA at the present time. Instead, triple rinse them, collect rinsate as waste, deface the original labels, and either discard or reuse the containers for waste collection.
- Original chemical reagent containers can make good waste collection containers, but they must be appropriate to the characteristics and properties of the waste. In general, glass bottles should be avoided unless they have a shatter-resistant coating, and metal

[1] Select locations must supply their own waste containers and pay for disposal services from separate funds, including UVA's College at Wise

containers should never be used for corrosive materials. Food and beverage containers are not suitable for chemicals and should never be used for waste. Limit waste containers to no larger than 5 gallons (~ 22 Liters) capacity. EHS can also provide suitable waste collection containers free-of-charge.

1 gallon bottle for liquid waste

5 gallon carboy for liquid waste



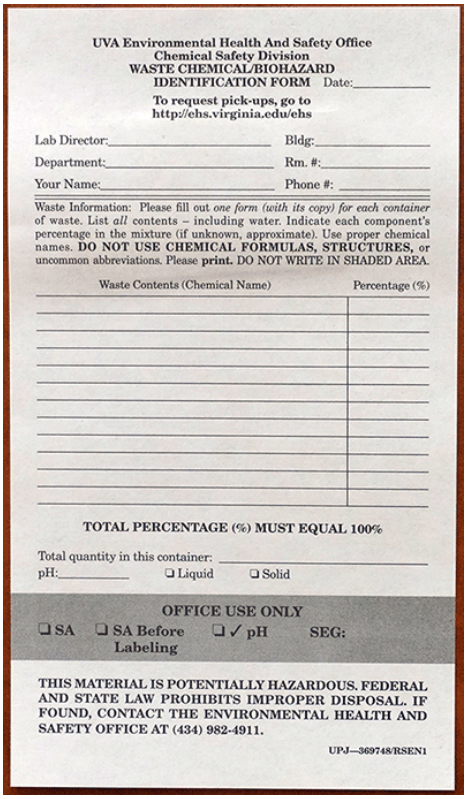
1 gallon bucket for solid & gel waste

5 gallon bucket for solid & gel waste

- Label every waste container with an approved EHS hazardous waste label, as shown below. Waste labels are automatically provided on containers supplied by EHS; they are also available from EHS for reusing chemical reagent bottles. A hazard pictogram must

be checked to indicate the hazard characteristic of the waste, along with details on the composition of the waste:

- Attach a completed waste disposal ticket to the top of each hazardous waste container prior to EHS pick up. Disposal tickets are required *in addition to* the hazardous waste labels. Fill in all of the information requested on the ticket:


UVA Environmental Health And Safety Office
Chemical Safety Division
WASTE CHEMICAL/BIOHAZARD
IDENTIFICATION FORM Date:_____

To request pick-ups, go to
http://ehs.virginia.edu/ehs

Lab Director:_____ Bldg:_____
Department:_____ Rm. #:_____
Your Name:_____ Phone #: _____

Waste Information: Please fill out *one form (with its copy) for each container* of waste. List *all* contents – including water. Indicate each component's percentage in the mixture (if unknown, approximate). Use proper chemical names. **DO NOT USE CHEMICAL FORMULAS, STRUCTURES,** or uncommon abbreviations. Please **print.** DO NOT WRITE IN SHADED AREA.

Waste Contents (Chemical Name)	Percentage (%)

TOTAL PERCENTAGE (%) MUST EQUAL 100%

Total quantity in this container: _____
pH:_____ ❑ Liquid ❑ Solid

OFFICE USE ONLY
❑ SA ❑ SA Before Labeling ❑ ✓ pH SEG:

THIS MATERIAL IS POTENTIALLY HAZARDOUS. FEDERAL AND STATE LAW PROHIBITS IMPROPER DISPOSAL. IF FOUND, CONTACT THE ENVIRONMENTAL HEALTH AND SAFETY OFFICE AT (434) 982-4911.

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- Do not completely fill liquid waste containers - leave a gap of at least 2 inches (about 5 cm) below the cap.

- Keep waste containers closed except when adding waste. For operations that continuously generate chemical waste (i.e., HPLC instrumentation), high volume waste operations, or for wastes that may evolve significant amounts of gas, contact EHS for samples of special container caps that can be used to accommodate continuous accumulations and prevent hazardous pressure build-up.
- Needles (chemically contaminated and non-contaminated), razor blades, scalpels, and other objects that pose a puncture or laceration hazard must be collected in a Sharps container for disposal as regulated medical waste. Only fill containers to about two-thirds of their capacity - then close and notify EHS for pick-up. No additional waste label or ticket is necessary. Sharps containers are available from EHS free-of-charge; Environmental Services (EVS) supplies and picks up sharps containers at Medical Center laboratory locations.
- Collect other chemically-contaminated items such as syringe barrels, capillary tubes, pipettes, and pipette tips in hazardous waste buckets.
- Store hazardous chemical wastes in your established laboratory satellite accumulation area, using secondary containment.
- Place non-contaminated glassware and other glass items in a bag-lined cardboard box and label it with an EHS "Waste Laboratory Glassware" sticker. Once full, close the bag and tape the box shut. These materials are managed as regular trash and can be removed by Housekeeping or taken directly to a trash dumpster.
- Unknown wastes can be dangerous to handle. In addition, they are not accepted by disposal firms. Every effort must be made to identify In the event that a waste (or any other chemical) container has unknown contents, contact EHS as soon as possible for assistance.
- When waste containers are ready for pick up, notify EHS by using the on-line Waste Pick-Up Request Form or calling (434) 982-4911.

Although generally of limited opportunity, laboratories are permitted to perform certain kinds of treatment in order to render a waste stream less or non-hazardous. Acid / base neutralizations are among the more common procedures as are some chemical-specific deactivations. If pursued, these in-laboratory treatments must be performed as part of an experiment or testing procedure and their effectiveness assured before broader adoption. It is essential to consult EHS for additional technical information and safety advice about any laboratory waste treatment before it can be an approved process.

Key References and Other Resources

Below are some useful standard reference materials on chemical and laboratory safety, many of which are available on-line, from EHS, or through the UVA library system. Contact EHS if you have any questions or additional information needs.

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Federal and State Regulatory Agencies

U.S. Department of Agriculture (USDA)
U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (US DHHS / CDC)
U.S. Department of Homeland Security (DHS)
U.S. Drug Enforcement Administration (DEA)
U.S. Environmental Protection Agency (EPA)
U.S. Occupational Safety and Health Administration (OSHA)
Virginia Board of Pharmacy (VBP)
Virginia Department of Environmental Quality (DEQ)
Virginia Department of Labor and Industry (DOLI)
Virginia State Fire Marshal's Office (SFMO)

Advisory Organizations

American Chemical Society, Division of Chemical Health and Safety (ACS-DCHAS)
American Conference of Governmental Industrial Hygienists (ACGIH)
American Industrial Hygiene Association (AIHA)
American National Standards Institute (ANSI)
Compressed Gas Association (CGA)
International Agency for Research on Cancer (IARC)
International Institute for Sustainable Laboratories (I2SL)
National Fire Protection Association (NFPA)
National Institute for Occupational Safety and Health (NIOSH)
National Toxicology Program (NTP)
U.S. Chemical Safety Board (CSB)

Some Useful Journals

Journal of Chemical Education
Journal of Chemical Health and Safety
Journal of Occupational and Environmental Hygiene
Journal of Occupational and Environmental Medicine

UVA Resources

EHS Website (http://ehs.virginia.edu)

Controlled Substances (https://research.virginia.edu/compliance/compliance-programs/controlled-substances)
UVA Facilities Management (https://www.fm.virginia.edu/)
UVA *Facility Design Guidelines* (https://www.fm.virginia.edu/services/construction.html)
UVA Student Health (https://www.studenthealth.virginia.edu/)
UVA Occupational Health (https://www.medicalcenter.virginia.edu/occupational-health)
UVA Office of Property & Liability Risk Management (https://riskmanagement.virginia.edu/)
UVA Policy Directory (https://uvapolicy.virginia.edu/)

Appendix 1. Glossary of Terms and Definitions

Acid An organic or inorganic compound with a pH < 7. Strongly acidic compounds are corrosive to human skin, eyes, and mucous membranes, and can damage metals and other materials.

Action Level An exposure limit designated by OSHA for a specific regulated substance, typically calculated on the basis of an eight (8)-hour time-weighted average. Exposure above the action level initiates certain required activities such as training and medical surveillance. Action levels are usually set at ½ the value of the **Permissible Exposure Limit**.

Acute Immediate. Acute describes short-term exposure as well as the symptoms or health effects that occur immediately after an exposure.

Acutely Toxic See **Highly Toxic**.

Aerosol Fine droplets of liquid or solid uniformly dispersed in a gaseous medium, usually air.

Air Reactive Chemicals that react with air to release a gas that is flammable or toxic.

Allergens Substances that can cause an allergic reaction. Common signs and symptoms of exposure to allergens include watering of the eyes, sneezing, coughing, and respiratory constriction. Examples of allergens include diazomethane, isocyanates, and chromium compounds.

American Conference of Governmental Industrial Hygienists (ACGIH) An advisory organization that develops and publishes occupational exposure limits known as **Threshold Limit Values** (TLVs). Because TLVs are reviewed annually and updated when new information becomes available, they are generally considered more protective that OSHA's **Permissible Exposure Limits**.

American National Standards Institute (ANSI) An advisory organization that develops and publishes consensus standards for a variety of equipment, systems, and testing procedures.

Asphyxiant A gas or vapor that can cause suffocation leading to unconsciousness or death. Simple asphyxiants (e.g., nitrogen, argon) displace oxygen from air, while chemical asphyxiants (e.g., carbon monoxide, hydrogen sulfide) interfere with biochemical processes to impede the absorption or transportation of oxygen to tissue.

Base An organic or inorganic compound with a pH > 7. Bases are also referred to as alkalis or caustic materials and are often corrosive or irritating to human tissue.

Blood and Blood System Hazards Chemicals that can damage the blood or hematopoietic system, or decrease hemoglobin function. Common signs and symptoms of over-exposure to these hazards include cyanosis, dizziness, and loss of consciousness. Carbon monoxide and the cyanides are examples of blood system hazards.

Boiling Point The temperature at which the vapor pressure of a liquid equals the atmospheric pressure and the liquid changes phase to vapor. Flammable liquids with low boiling points are volatile and pose high fire hazards.

Carcinogen Any chemical or physical agent that causes cancer. A subset of carcinogens, known as **select carcinogens**, are considered particularly hazardous under OSHA's *Laboratory Standard*.

Caustic Any strongly alkaline material that can produce corrosion or irritation to living tissue.

Ceiling Limit (C) An occupational exposure limit representing the airborne concentration of a chemical that should not be exceeded for any period of time.

Chemical Fume Hood An enclosed or partially enclosed device with a movable sash, connected to ductwork and exhausted outdoors, used to capture and remove airborne contaminants during chemical handling and other operations. Chemical fume hoods are the most common and important engineering control in most laboratories.

Chemical Hygiene Officer An individual designated by the employer, and qualified by training or experience, to provide technical guidance in the development and implementation of the Chemical Hygiene Plan. At UVA, the EHS Chemical Safety Officer serves as the institutional Chemical Hygiene Officer.

Chemical Hygiene Plan A written program developed and implemented by the employer that outlines procedures, equipment, personal protective equipment, and work practices to protect individuals from the hazards of chemicals used in a **laboratory**.

Chronic Repeated, persistent, or long-term. Chronic can refer to exposures that occur over a long period of time (often at low levels) and to symptoms or health effects that have a long **latency** period or that tend to be persistent.

Combustible Liquid Capable of catching on fire and burning. Combustible liquids have a flashpoint at or above 100° F (37.8° C) but below 200° F (93.3° C), and are less hazardous than

flammable liquids.

Compressed Gas A contained gas, mixture of gases, or liquid with an absolute pressure significantly above atmospheric pressure. Compressed gases used in laboratories commonly have internal cylinder pressures of thousands of pounds per square inch (PSI).

Corrosive A chemical that causes visible destruction or irreversible alterations to living tissue at the site of contact. Corrosive chemicals are also often destructive to metal and other materials.

Cryogenic Liquid Extremely cold liquids that pose a risk of serious tissue damage from immersion or splash contact. Their very high liquid:gas expansion ratio can also pose an asphyxiation hazard from rapid oxygen displacement, while flammable cryogenic liquids (e.g., liquid hydrogen) can pose serious explosion hazards.

Dermal Hazards Chemicals that damage the dermis (i.e., skin). Signs and symptoms of over-exposure include skin defatting, blanching or reddening, rashes, and localized irritation. Ketones, phenol, and chlorinated compounds are common dermal hazards.

Dermatitis Inflammation of the skin, resulting either from local irritation effects or an allergic immunologic reaction.

Designated Areas Locations within a laboratory used to work with **particularly hazardous substances**. A designated area may be an entire laboratory room or a subset of the room such as a specific bench-top, chemical fume hood, or glovebox.

Dry Ice Solid carbon dioxide which converts directly to carbon dioxide gas at -78° C (-109° F).

Dyspnea Shortness of breath.

Embryotoxin A substance capable of adversely affecting a developing embryo but that does not necessarily affect the pregnant female.

Engineering Control Equipment and devices used to minimize or eliminate exposures. Engineering controls typically function by isolating, containing, and/or exhausting hazardous materials. Chemical fume hoods, snorkels, glove boxes, and splash or “blast” shields are common laboratory engineering controls.

Environmental Protection Agency (EPA) The U.S. federal agency responsible for promulgating and enforcing environmental regulations, including those for managing hazardous chemical waste.

Erythema Reddening of the skin.

Explosive A chemical that undergoes reaction so rapidly and releases so much gas that it exerts a high pressure on the surroundings. Explosives can be initiated by mechanical shock, heat, light, or chemical catalysts. Less energetic reactions are known as deflagrations. In the laboratory, explosives may be under purposeful study or examination, but are more commonly encountered as accidental chemical by-products, residues, or decomposition products with known explosive functional groups.

Eye Hazards Chemicals that affect the eyes. Conjunctivitis and corneal damage are common signs of over-exposure or injury from these chemicals. Examples of chemical eye hazards in the laboratory include acids, bases, osmium tetroxide, and most organic solvents.

Fires Fires are physico-chemical reactions that require a combination of fuel, oxygen, and a source of ignition to start. They are classified as follows:

- Class A: Ordinary combustibles such as wood, paper, cloth, rubber, and most plastics.
- Class B: Flammable and combustible liquids.
- Class C: Electrical devices and equipment such as computers, wiring, extension cords, and electrical laboratory equipment.
- Class D: Combustible, flammable, or pyrophoric materials such as magnesium, potassium, sodium, and butyl lithium.

Flammable Chemicals that meet one or more of the following criteria:

- Liquids with a flashpoint below 100° F,
- Gases and vapors that can form an ignitable mixture in air,
- Aerosols that can produce a long flame or flashback,
- Solids that can cause fire when exposed to friction, moisture, spontaneous chemical change, or retained heat, or ignite readily and burn vigorously and persistently.

Flashpoint (FP) The lowest temperature at which vapors can form above a liquid in a concentration sufficient to form an ignitable vapor:air mixture.

Fumes A suspension of fine particles in air.

General Ventilation General ventilation refers to mechanical systems that supply and exhaust air from a room. Laboratories are usually designed with 100% exhaust, meaning that laboratory room air is not recirculated to other spaces in a building for safety and health reasons. General ventilation is used to control odors and minor fugitive emissions, but is not effective for controlling hazardous exposures (for which **local exhaust ventilation** is needed).

Hazardous Material or Chemical A substance with statistically-significant evidence of causing harm. Chemicals may pose health hazards, physical hazards, or a combination of both.

Hepatotoxins Chemicals that can produce liver damage. Signs and symptoms of over-exposure to a hepatotoxin include jaundice and liver enlargement. Examples of hepatotoxins include carbon tetrachloride and nitrosamines.

Highly Toxic Highly poisonous, high potential to exert harmful effects. Under OSHA definitions, a chemical or other substance is classifiable as highly toxic if it exhibits any of the following characteristics when administered to research animals under standard test conditions:

- Oral LD_{50} of 50 milligrams or less per kilogram of body weight, or
- Dermal LD_{50} of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours), or
- Inhalation LC_{50} in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour).

Immediately Dangerous to Life and Health (IDLH) The concentration of an airborne contaminant that poses a serious risk of death or immediate or delayed permanent health effects, or that impedes or prevents an individual from escaping the area.

Incompatible Two or more substances that can result in a dangerous reaction when mixed together, often generating high heat, rapid polymerization, or the evolution of harmful gases.

Ingestion Route of administration or exposure by eating, drinking, or accidental transfer to the mouth.

Inhalation Route of administration or exposure by breathing in a gas, vapor, mist, aerosol, fume, or dust.

Inhibitor An additive used to reduce or prevent unwanted changes or reactions in a chemical.

Irritant A substance that can cause reversible inflammation to the eyes, nose, skin, or respiratory system.

Laboratory A facility where the **laboratory use of hazardous chemicals** occurs. It is a location where relatively small quantities of hazardous chemicals are used on a non-production basis.

Laboratory Scale Work with chemicals where reactions, transfers, and other handling are performed in containers and other vessels that can be easily and safely manipulated by one person.

Laboratory Use of Hazardous Chemicals Handling and use of hazardous chemicals in which all of the following conditions are met:

- Chemical manipulations are carried out on the **laboratory scale**, and
- Multiple procedures or chemicals are used, and
- Procedures are not part of a production process nor do they in any way simulate a production process, and
- Protective laboratory practices and equipment are available and in common use to minimize potential exposures to chemicals.

Latency The time lag or delay between exposure to a harmful agent and the first appearance of health effects.

Lethal Concentration 50% (LC_{50}) The airborne concentration of a substance that will kill 50% of a test population when administered by continuous inhalation for one hour or less. LC_{50} data are used to classify the inhalation toxicity of a contaminant, and are typically reported in units of parts per million (ppm) for gases or vapors, and mg/L for mists, fumes, and dusts.

Lethal Dose 50% (LD_{50}) The quantity of a substance that will kill 50% of a test population when administered orally or by continuous skin contact for 24 hours or less. LD_{50} data are used to classify the toxicity of a material by the routes of oral and dermal exposure, generally reported as mg per kg of body weight.

Leukemia Cancer of the white blood cells (leukocytes).

Local Exhaust Ventilation An engineered device that is part of a system for exhausting contaminants directly from their point of generation. Chemical fume hoods are the most common local exhaust ventilation device in UVA laboratories.

Lower Explosive Limit (LEL) The minimum concentration of a flammable material in air needed to ignite. Concentrations below the LEL are too "lean" to burn.

Melting Point (mp) The temperature at which substances change phase from solid to liquid.

Mist A uniform suspension of fine liquid droplets in air.

Mutagen A chemical or physical agent that can causes mutations in DNA.

Narcosis Central nervous system health effects that include unconsciousness, dizziness, confusion, or stupor.

National Institute for Occupational Safety and Health (NIOSH) Agency within the U.S. Centers for Disease Control and Prevention, responsible for basic and applied research to reduce workplace injuries and illnesses.

Nephrotoxins Chemicals that can produce kidney (renal) damage. Signs and symptoms of over-exposure to nephrotoxins include edema and proteinuria. Examples of nephrotoxic chemicals include halogenated hydrocarbons and heavy metals.

Neurotoxins Chemicals that produce toxic effects on the nervous system. Common signs and symptoms of over-exposure to neurotoxins include narcosis, behavioral changes, and a decrease in motor function. Examples of neurotoxins in the laboratory include mercury, carbon disulfide, and MPTP.

Neutralize The process of increasing or lowering the pH of an aqueous solution to approximately 7.

Occupational Safety and Health Administration (OSHA) Agency within the U.S. Department of Labor, responsible for establishing and enforcing workplace safety and health standards.

Odor Threshold The concentration of a substance to which most people can detect and identify it by smell.

Organic Material Any chemical containing carbon.

Organic Peroxides Organic compounds that contain the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

Oxidizers Chemicals that initiate or promote combustion in other material through the release of oxygen.

Oxygen Deficiency An atmosphere that contains less than the normal concentration of 20.9% oxygen at standard temperature and pressure.

Particularly Hazardous Substances Under OSHA's *Laboratory Standard*, particularly hazardous substances are defined as select carcinogens, reproductive toxins, and acutely / highly toxic chemicals.

Permissible Exposure Limit (PEL) An exposure limit designated by OSHA for a specific substance. PELs may be established on the basis of exposure over an eight (8)-hour time-weighted average (TWA), a 15-minute short term exposure limit (STEL), or as a maximum or ceiling (C) concentration that may not be exceeded at any time. PELs are listed by OSHA in 29 CFR 1910.1000 and their substance-specific standards under Subpart Z. Because PELs must also account for feasibility and can only be revised through the regulatory process, occupational exposure limits from other groups such as NIOSH and ACGIH generally reflect more up-to-date information.

Personal Protective Equipment (PPE) Garments, clothing, and other equipment worn for protection from hazardous materials. Safety glasses, laboratory coats, and gloves are the most common PPE used in laboratories.

Poison Toxic. Any substance which is harmful to life, generally in small quantities or doses.

Polymerization A chemical reaction in which smaller molecules combine to former larger molecules linked together with repeating structural units. Rapid, uncontrolled polymerization reactions can be dangerous due to their rapid release of energy (heat), especially when performed without adequate cooling or venting.

Pyrophoric A solid or liquid chemical that can spontaneously ignite upon exposure to air.

Reactivity The ability of a substance to undergo a chemical or physical reaction that can result in dangerous effects such as rapid increases in pressure or temperature, or the formation and evolution of toxic or corrosive products.

Recommended Exposure Limit (REL) Occupational exposure limits established by NIOSH, without regard to the feasibility of achieving them in the workplace. Like **Threshold Limit Values**, RELs are reviewed frequently and updated as new information becomes available, often making them more up-to-date and protective than OSHA's **permissible exposure limits**.

Reproductive Toxins Chemicals that can affect reproductive capabilities, including chromosomal damage (mutations) and fetal malformations (teratogenesis). Signs and symptoms of over-exposure to reproductive toxins include birth defects and sterility (male or female). Lead, DBCP, and thalidomide are well-known reproductive toxins.

Respirable Ability of an airborne substance to be drawn into the deep alveolar region of the lungs. Gases, vapors, and fine particles are respirable.

Respirator A personal protective equipment device worn to protect against respiratory hazards. Respirators may filter or purify contaminants from breathing air or they may supply air through a hose or compressed air tank. Improper respirator selection, use, or maintenance can place the user at serious risk of injury or death. Anyone needing to wear a respirator must first contact EHS in order to receive proper training, medical clearance, and be fit tested.

Respiratory Hazards Substances that result in bodily injury or illness after breathing them. Injuries may occur to the upper, middle, or lower deep airways, or elsewhere in the body after contaminant diffusion and transport.

Safety Data Sheet (SDS) Formerly known as Material Safety Data Sheets, SDSs are technical information documents that must be developed and distributed by chemical manufacturers, importers, and other supplies. They provide important basic information about the properties of a chemical or chemical product. They also provide guidance on safe handling and emergency response procedures.

Select Agent Toxin Toxins of biological, recombinant, or synthesized origin regulated under the U.S. *Federal Select Agent Program* which is jointly administered by the Centers for Disease Control and Prevention and the Department of Agriculture. Under this program, select agent toxins are the toxic material or product of:

- Plants, animals, or microorganisms (including, but not limited to: bacteria, viruses, fungi, rickettsia, or protozoa), or
- Infectious substances, or
- A recombinant or synthesized molecule, whatever their origin and method of production, and includes:
    - Any poisonous substance or biological product that may be engineered as a result of biotechnology, produced by a living organism, or
    - Any poisonous isomer or biological product, homolog, or derivative of such a substance.

Select Carcinogens Select carcinogens are a subset of carcinogenic chemicals that meet one or more of the following criteria:

- Regulated by OSHA as a carcinogen; or
- "Known to be carcinogens" by the National Toxicology Program (NTP); or
- Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer (IARC); or

- Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP, and cause a statistically-significant increase in the incidence of tumors in experimental animals under specified conditions.

Sensitizer A chemical that can result in an allergic response, often only after multiple or repeated exposures. Isocyanates and metallic nickel are two common examples of chemical sensitizers.

Short Term Exposure Limit (STEL) An average concentration for air contaminants to which workers may be safely exposed for a maximum duration of 15 minutes.

"Skin" A clarifying designation for occupational exposure limits for chemicals with a potential for significant dermal absorption.

Sublimation A type of phase transition; solid substance changing directly to a gas without ever going through the liquid phase.

Systemic Usually referring to a hazardous material, meaning broadly distributed or affecting some or all of the organ systems of the body.

Teratogens Chemical and physical agents capable of causing defects or death in developing embryos or fetuses after exposure to the pregnant female.

Threshold Limit Value (TLV) Recommendations from the ACGIH for exposures to air contaminants that are believed to protect most workers from adverse effects, based upon epidemiologic and animal study data. TLVs may take the form of 8-hour time-weighted averages, 15-minute short-term exposure limits, or ceiling limits. Since TLVs are reviewed annually and updated as new information becomes available, they are often more up-to-date and protective than OSHA's permissible exposure limits.

Time Weighted Average (TWA) The average concentration of a contaminant measured over a specified period of time.

Toxic Poisonous, potential to exert harmful effects. Under OSHA definitions, a chemical or other substance is classifiable as toxic if it exhibits any of the following characteristics when administered to research animals under specified test conditions:

- Oral LD_{50} of more than 50 milligrams per kilogram but not more 500 milligrams per kilogram of body weight when administered orally, or

- Dermal LD_{50} of more than 200 milligrams per kilogram but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours), or
- Inhalation LC_{50} in air of more than 200 parts per million but not more than 2,000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour).

Unstable A chemical that can vigorously polymerize, decompose, or become self-reactive under conditions of shock, age, exposure to air, or changes in pressure or temperature.

Upper Explosive Limit (UEL) The maximum concentration of a flammable material in air that will ignite. Concentrations above the UEL are too "rich" to burn.

Vapor Pressure (VP) The pressure exerted from liquid vapors, typically reported in units of millimeters of mercury (mm Hg) or Pascals (Pa). Normal atmospheric pressure is about 760 mm Hg. The higher the VP of a liquid, the more volatile it is and the more rapidly it evaporates, making VP a key factor to consider during chemical hazard assessment.

Water-Reactive A chemical that reacts with water and releases a gas that is either flammable or toxic.

Appendix 2. OSHA Laboratory Standard

(a) Scope and application.

(1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(2) Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

(i) For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(iii) Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.

(3) This section shall not apply to:

(i) Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart 2, even if such use occurs in a laboratory.

(ii) Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

(A) Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

(B) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

(b) Definitions -

"Action level" means a concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Carcinogen" (see "select carcinogen").

"Chemical Hygiene Officer" means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

"Chemical Hygiene Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

"Combustible liquid" means any liquid having a flashpoint at or above 100 deg. F (37.8 deg. C), but below 200 deg. F (93.3 deg. C), except any mixture having components with flashpoints of 200 deg. F (93.3 deg. C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Compressed gas" means:

(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or

(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg C) regardless of the pressure at 70 deg. F (21.1 deg. C); or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 C) as determined by ASTM D-323-72.

"Designated area" means an area which may be used for work with "select carcinogens," reproductive toxins or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, such as a laboratory hood.

"Emergency" means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

"Employee" means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

"Explosive" means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

"Flammable" means a chemical that falls into one of the following categories:

(i) "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;

(ii) "Gas, flammable" means:

(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or

(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

(iii) "Liquid, flammable" means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(iv) "Solid, flammable" means a solid, other than a blasting agent or explosive as defined in 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous

chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24 - 1979 (ASTM D 56-79)) - for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7 - 1979 (ASTM D 93-79)) - for liquids with a viscosity equal to or greater than 45 SUS at 100 deg. F (37.8 deg. C), or that contain suspended solids, or that have a tendency to forma a surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)).

Organic peroxides, which undergo auto-accelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

"Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

"Laboratory" means a facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

"Laboratory scale" means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safety manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

"Laboratory-type hood" means a device located in a laboratory, enclosure on five sides with a movable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the

laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

"Laboratory use of hazardous chemicals" means handling or use of such chemicals in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a "laboratory scale;"
(ii) Multiple chemical procedures or chemicals are used;
(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and
(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

"Medical consultation" means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

"Organic peroxide" means an organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

"Oxidizer" means a chemical other than a blasting agent or explosive as defined in 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

"Physical hazard" means a chemical for which there is scientifically valid evidence tat it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive) or water-reactive.

"Protective laboratory practices and equipment" means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

"Reproductive toxins" means chemicals which affect the reproductive chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

"Select carcinogen" means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or
(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP)(latest edition); or
(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(A) After inhalation exposure of 6 - 7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3);

(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(C) After oral dosages of less than 50 mg/kg of body weight per day.

"Unstable (reactive)" means a chemical which is the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

"Water-reactive" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

(c) Permissible exposure limits. For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.

(d) Employee exposure determination

(1) Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

(2) Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

(3) Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.

(4) Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

(e) Chemical hygiene plan - General. (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan.)

(1) Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

(i) Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and

(ii) Capable of keeping exposures below the limits specified in paragraph (c) of this section.

(2) The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

(3) The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection;

(i) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;
(ii) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;
(iii) A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;
(iv) Provisions for employee information and training as prescribed in paragraph (f) of this section;
(v) The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;
(vi) Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;
(vii) Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee; and
(viii) Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:
(A) Establishment of a designated area;
(B) Use of containment devices such as fume hoods or glove boxes;
(C) Procedures for safe removal of contaminated waste; and
(D) Decontamination procedures.

(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

(f) Employee information and training.

(1) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.
(2) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.
(3) Information. Employees shall be informed of:
(i) The contents of this standard and its appendices which shall be made available to employees;
(ii) the location and availability of the employer's Chemical Hygiene Plan;
(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
(iv) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

(v) The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.

(4) Training.

(i) Employee training shall include:

(A) Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

(B) The physical and health hazards of chemicals in the work area; and

(C) The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

(g) Medical consultation and medical examinations.

(1) The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

(i) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.

(ii) Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

(iii) Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

(2) All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

(3) Information provided to the physician. The employer shall provide the following information to the physician:

(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;

(ii) A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and

(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.

(4) Physician's written opinion.

(i) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

(A) Any recommendation for further medical follow-up;
(B) The results of the medical examination and any associated tests;
(C) 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 workplace; and
(D) 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.

(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

(h) Hazard identification.

(1) With respect to labels and material safety data sheets:

(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

(ii) Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

(2) The following provisions shall apply to chemical substances developed in the laboratory:

(i) If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.

(ii) If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.

(iii) If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.120) including the requirements for preparation of material safety data sheets and labeling.

(i) Use of respirators. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

(j) Recordkeeping.

(1) The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

(2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

(k) Dates

(1) Effective date. This section shall become effective May 1, 1990.

(2) Start-up dates.

(i) Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.
(ii) Paragraph(a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

(l) Appendices. The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.