CHEMICAL HYGIENE PLAN

Environmental Health & Safety

Columbia University

Revised, December 2024

Introduction

The Chemical Hygiene Plan (CHP) is a requirement for non-production laboratories where chemicals are used in accordance with OSHA's Occupational Exposure to Hazardous Chemicals in Laboratories standard (29 CFR 1910.1450), more commonly referenced as the Laboratory Standard. This plan applies to faculty, staff and students on all Columbia University campuses, including the New York State Psychiatric Institute (NYSPI), engaged in the laboratory-based use of hazardous materials.

The CHP does not address the use of radioactive materials or biological agents. Information on these materials can be found in the University's Radiation Safety Manual and Biosafety Manual, respectively.

Overview of Regulatory Information

OSHA's Occupational Exposure to Hazardous Chemicals in Laboratories standard (29 CFR 1910.1450), commonly referred to as the Laboratory Standard, specifies the mandatory requirements of a Chemical Hygiene Plan (CHP) to protect laboratory workers from harm due to exposure to hazardous chemicals. The CHP is a written record stating the policies, procedures and responsibilities that protect workers from the health hazards associated with the hazardous chemicals used in that particular workplace.

Some key components of a CHP include:

- Information for the determination and proper implementation of control measures to reduce employee exposure to hazardous chemicals
- Requirements for safety training of employees that would help in mitigating risks
- Criteria for medical consultation and examinations in the event of an exposure
- Requirements for the handling of highly hazardous chemicals
- Procedures for hazardous waste disposal
- Emergency response procedures in the event of accidental release, fire or injuries

Roles and Responsibilities in Research

Principal Investigator (PI)

The Principal Investigator (PI) is a faculty member or research scientist appointed by the University to conduct research. The PI has overall responsibility for safety and compliance in their laboratory, although the below responsibilities can be delegated to a competent designee(s) in the laboratory. The PI is responsible for:

a. Promoting, by example and instruction, an overall culture of safety and an environmentally sound workplace, including personal adherence to applicable laboratory attire, laboratory hygiene, and personal protective equipment standards.
b. Ensuring that laboratory personnel have read, understand and adhere to this document and its associated Plans, including the Laboratory Assessment Tool and Chemical Hygiene Plan (LATCH), and all University, school, departmental and laboratory policies and procedures.
c. Completing all required training courses, and ensuring that new laboratory personnel attend Laboratory Safety, Chemical Hygiene and Hazardous Waste Management Training, and all other applicable safety training at the time of hire or before involvement in laboratory research activities, and that refresher training is completed as required.
d. Ensuring that current and new laboratory personnel receive adequate laboratory process and/or equipment-specific safety training before participation or use.
e. Ensuring that personnel are advised of potential hazards and corresponding applicable safety procedures when joining the laboratory, and when introducing new hazardous biological or chemical substances, radioactive materials, compressed gasses, equipment, and procedures.
f. Ensuring that appropriate personal protective equipment (PPE) is available, used, and maintained, and that appropriate laboratory attire is worn by all laboratory personnel.
g. Developing operating procedures to address a particular hazard or operation encountered in the laboratory. EH&S may be consulted to determine which operations warrant documentation as a standard operating procedure (SOP).
h. Ensuring that proper signage is present inside the laboratory to identify where hazards may exist.

i. Ensuring that containers are labeled so that laboratory personnel and/or emergency responders can determine the identity of their contents.
j. Ensuring that a FDNY Certificate of Fitness (CoF) holder is present in the laboratory at all times when personnel are working in the laboratory.
k. Reviewing the laboratory's operating procedures, plans, including the LATCH, and other relevant safety documents and materials, whenever changes occur, but no less frequently than annually.
l. Completing Vacating Procedures prior to any laboratory renovation or move.

Laboratory Safety Manager

The Laboratory Safety Manager is a senior researcher appointed by the PI or is the PI themselves, who is responsible for all safety aspects of the laboratory's operations. The Laboratory Safety Manager is responsible for:

a. Working and conducting themselves in a manner that supports an overall culture of safety and an environmentally sound workplace.
b. Maintaining a current FDNY Certificate of Fitness (CoF) for Supervising Chemical Laboratories (C-14). Another individual(s) may be designated to obtain the CoF, which can be obtained by passing a test administered by EH&S, as authorized by FDNY.
c. Working with the PI and EH&S to ensure laboratory personnel are informed of and follow this document, its associated Plans, including the LATCH, and all University, school, departmental and laboratory policies and procedures. Ensuring laboratory personnel conduct activities in a manner consistent with good laboratory practices.
d. Addressing compliance and/or safety observations made by EH&S during the course of routine laboratory surveys, regulatory inspections or other specialized reviews.
e. Reviewing and adhering to the Columbia University Policy for Personal Protective Equipment in Research Laboratories.
f. Ensuring that appropriate PPE is available, used and maintained, and that appropriate laboratory attire is worn by all laboratory personnel.
g. Ensuring that appropriate spill control material is available, and personnel are trained in its use.
h. Ensuring that Safety Data Sheets (SDS) are accessible, either on paper or electronically, for all hazardous chemicals in use or storage.
i. Instructing laboratory personnel on specific procedures and equipment.
j. Ensuring that chemical containers are properly labeled and closed.
k. Ensuring that a chemical inventory is prepared, maintained and accessible, either on paper or electronically (e.g., ChemTracker).
l. Monitoring the procurement, use, and disposal of hazardous substances.
m. Advising Facilities personnel and other visitors of potential hazards that might be encountered when they enter the laboratory.

Laboratory Personnel are individuals who work in the laboratory including PIs, research scientists, post-doctoral fellows, technicians, undergraduate and graduate students, visiting scientists, laboratory volunteers, and support personnel, such as glassware washers and autoclave operators. All laboratory personnel are responsible for:

a. Working and conducting themselves in a manner that supports an overall culture of safety and an environmentally sound workplace.
b. Reviewing and applying the information in this document, its associated Plans, including the LATCH, and all University, school, departmental and laboratory policies and procedures.
c. Reviewing and adhering to the Columbia University Policy for Personal Protective Equipment in Research Laboratories.
d. Knowing where SDSs are maintained and reviewing SDSs prior to use of hazardous substances.
e. Attending Laboratory Safety, Chemical Hygiene and Hazardous Waste Management Training and other applicable trainings, and maintaining current refresher status with all training requirements.
f. Safely handling and disposing of chemicals and other laboratory wastes.
g. Using appropriate engineering controls (e.g., biological safety cabinet, chemical fume hood, radiation shielding) and PPE when working in the laboratory, and wearing appropriate laboratory attire at all times.
h. Reviewing and understanding emergency response procedures.
i. Reporting hazards to the Laboratory Safety Manager, PI and/or EH&S.

Environmental Health & Safety (EH&S)

Columbia University Environmental Health & Safety (EH&S) serves as the primary health and safety resource to assist laboratories in promoting best practices in safety and environmental performance in all education and research activities, while maintaining compliance with applicable federal, state and local regulatory requirements, agreements and permits, including implementation of each laboratory's specific LATCH in compliance with the OSHA Standard 29 CFR 1910.1450. EH&S is responsible for**:**

a. Providing technical support and assistance in the areas of chemical safety, radiation safety, hazardous waste management, biological safety, industrial hygiene and occupational safety, fire/life safety and environmental stewardship.
b. Developing and implementing the University-wide Laboratory Safety and Chemical Hygiene Plan. EH&S reviews the program annually for regulatory compliance including federal, state, and city regulations, and represents Columbia University to the various federal, state, and city regulatory agencies.
c. Developing and implementing training and educational programs designed to improve the health and safety of the Columbia University community and to foster compliance with governmental regulations and professional standards.

d. Conducting regular visits to laboratories to assist in compliance with the Plan.
e. Implementing policies approved by the Columbia University Institutional Health and Safety Council.

Institutional Health and Safety Council (IHSC)

The Institutional Health and Safety Council, chaired by the Executive Vice President for Research, receives reports on various health, safety, and environmental issues and initiatives from EH&S and other University departments. The Council is comprised of EH&S personnel, various safety committee chairs, representatives of additional stakeholder units within the University and its partners, and senior laboratory-based faculty, chairpersons, and administrators.

Faculty Advisory Committee on Environmental Health & Safety (FACES)

The Faculty Advisory Committee on Environmental Health & Safety (FACES) supports and advances Columbia University's continued commitment to promoting best practices in safety and environmental performance in all education and research activities, while remaining compliant with applicable federal, state and local regulatory requirements, agreements and permits.

FACES assists EH&S with the establishment of research safety and environmental program goals based on issues and objectives deemed to be priorities by Committee members representing Columbia University's research enterprise. These programs are based on the concept of continual improvement, whereby the University strives to enhance safety and environmental performance by establishing objectives and targets and periodically monitoring performance against these targets. The committee meets on an as-needed basis.

University Research Safety Committee

The University Research Safety Committee acts in a consultative and advisory capacity to the Institutional Health and Safety Council to assure that the University's portfolio of research safety programs reflects its mission, strategic priorities and goals. To this end, the Committee, comprised of University scientists and science department administrators, works closely with EH&S and its institutional partners to continuously improve the overall culture of research safety at Columbia University. The Committee reviews relevant data on the condition of University laboratories, personnel safety behaviors and compliance trends, examines best practices and benchmarks, and recommends University policy and program enhancements in response. The Committee also reviews accident and incident reports and recommends program improvements, where necessary, and communicates relevant committee activities to University stakeholders.

1.1 Chemical Hygiene Plan Scope and Application

The CHP consists of two parts. The first outlines the University's policy for chemical hygiene and management in research laboratories by providing guidance for the safe use of chemicals, health hazards and routes of exposure, controlling or minimizing potential exposure, medical surveillance, training, waste disposal and emergency procedures. The second part, an essential component of the CHP, is a web-based Laboratory Assessment Tool and Chemical Hygiene Plan (LATCH) developed by EH&S, designed to help individual laboratories prepare a laboratory-specific CHP, as required by OSHA. The PI and/or their designee is responsible for completing the laboratory-specific LATCH and reviewing and updating it no less frequently than annually.

The PI must ensure that all laboratory personnel**:**

a. Are knowledgeable about the contents of the University's CHP and their laboratory-specific LATCH and how to access these plans.
b. Have attended Laboratory Safety, Chemical Hygiene & Hazardous Waste Training, and other necessary function-specific training.
c. Are trained in laboratory- or job-specific procedures and use of equipment before handling hazardous chemicals and equipment.
d. Are familiar with the hazards in the laboratory and understand emergency procedures.

1.1.1 Chemical Hygiene Officer (CHO)

The Chemical Hygiene Officer (CHO) is an employee who is designated by the employer, and who is qualified by training and/or experience, to provide technical guidance in the development and implementation of the provisions of the CHP. EH&S's Director, who serves as the University CHO, is responsible for:

a. Keeping the senior administration informed on the progress of continued implementation of the CHP and bringing campus-wide issues affecting laboratory safety to their attention.
b. Reviewing the University's CHP, at least annually, with University stakeholders and recommending revisions and improvements based on regulatory changes, external or internal lessons learned, and best practices designed to improve laboratory practices and the CHP.
c. Providing expert guidance to the laboratory community in the area of chemical safety and serving as a point of contact for inquiries.
d. Ensuring that guidelines are in place and communicated for Particularly Hazardous Substances regarding proper labeling, handling, use, and storage, selection of PPE, and facilitating the development of standard operating procedures for laboratories using these substances.
e. Serving as a resource for reviewing SOPs developed by PIs and laboratory personnel for the use, disposal, spill cleanup, and decontamination of hazardous chemicals, and the proper selection and use of personal protective equipment.
f. Reviewing reports of laboratory incidents, accidents, chemical exposures, and near misses and recommending follow-up actions where appropriate.
g. Disseminating information to relevant stakeholders regarding laboratory incidents, accidents, chemical exposures, and near misses.

h. Maintaining records of exposure monitoring and medical examinations.
i. Consulting on a laboratory worker's return to work following a chemical exposure requiring medical consultation.
j. Advising on the acquisition, testing and maintenance of fume hoods and overhead emergency showers and eyewashes in laboratories where hazardous chemicals are used.
k. Staying informed of plans for renovations or new laboratory construction projects and serving as a resource in assisting with the design and construction process.
l. Assisting in the overall administration of the University's research safety training programs.

1.2 Health and Physical Hazards of Chemicals

OSHA broadly defines *hazardous chemical* as any chemical that is classified as a health hazard or simple asphyxiant in accordance with the Hazard Communication Standard (29 CFR 1910.1200). *Health hazard* means a chemical that is classified as posing one of the following hazardous effects: acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenicity; reproductive toxicity; specific target organ toxicity (single or repeated exposure) or aspiration hazard. The criteria for determining whether a chemical is classified as a health hazard are detailed in Appendix A of the Hazard Communication Standard (§1910.1200).

1.2.1 Chemical Hazard Identification and Labeling

The CHP ensures that information about chemical and physical hazards is communicated to laboratory personnel and students who may potentially come into contact with hazardous materials in laboratories. Effective hazard communication includes, but is not limited to: maintenance of current chemical inventories, providing ready access to Safety Data Sheets (SDS) for hazardous chemicals, proper labeling of chemical containers, posting of hazard signs where relevant, and training of laboratory personnel with regard to relevant hazards.

As of June 1, 2015, the OSHA Hazard Communication Standard (HCS) requires pictograms on labels to alert users of the chemical hazards to which they may be exposed. Hazard pictograms form part of the international Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Each pictogram consists of a symbol on a white background framed within a red border and represents the chemical's distinct hazard(s). The pictogram on the label is determined by the chemical hazard classification. All chemical containers in Columbia University laboratories must be in compliance with GHS labeling requirements. Chemicals that are transferred to a secondary container can either be labeled with all of the required information that is on the label from the chemical manufacturer or, the product identifier and words, pictures, symbols or a combination thereof, which in combination with other information immediately available to employees, provide specific information regarding the hazards of the chemicals.

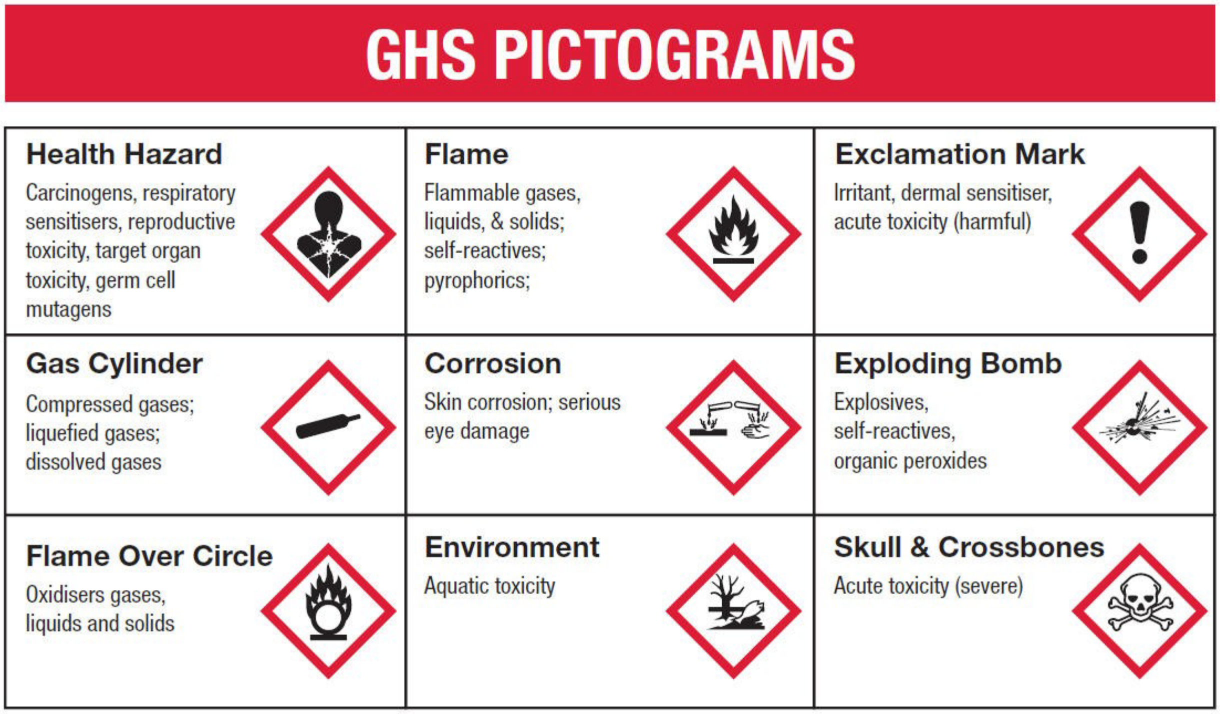

Figure 1: Globally Harmonized System of Labeling - Hazard Pictograms

1.2.2 Safety Data Sheets

Chemical manufacturers are required to evaluate the hazards of chemicals they produce or import, and to provide this information to purchasers, at the time of shipment, through SDSs. SDSs provide important information about a chemical's constituents, emergency aid and response measures, hazards, exposure control and personal protective equipment, and other information. Under OSHA's alignment of the Hazard Communication Standard with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS), all hazardous chemicals manufactured in or imported to the United States of America will have accompanying SDSs in a standardized 16-section format.

Laboratory staff are required to have immediate access to SDSs to aid them in evaluating the potential hazards of a substance prior to its use, as well as in the event of an emergency. SDS access and management is made available to all Columbia University research laboratories via ChemWatch. ChemWatch is a web-based database of more than 10 million SDSs, available in

English and over 30 foreign languages, for immediate access by Columbia University personnel. Staff or students who desire a copy of the SDS for any hazardous chemical with which they work or to which they may be exposed can also contact their PI, supervisor, instructor or EH&S for a copy.

Safety Data Sheets must be provided by any laboratory that ships hazardous chemicals. This requirement includes all research samples, regardless of quantity, that are shipped in transit. SDS must be prepared for novel or unique compounds based on an evaluation of the material's hazardous properties. Such lab-prepared SDSs shall include recommendations and instruction for the use of personal protective equipment, engineering controls and other information, as required. Please contact EH&S for additional guidance in developing SDSs for novel compounds.

1.2.3 Labels

Commercial suppliers of chemicals are required to label containers with the contents' chemical name(s), hazard information, and safe storage conditions. These labels must never be defaced or obstructed unless an emptied and rinsed container is to be used for another purpose. Chemicals produced within laboratories must also be labeled in English to meet these requirements.

When chemicals are transferred from primary, labeled containers to portable, secondary containers/vessels, the New York City Fire Code requires labeling of the portable, secondary container with a chemical name(s). OSHA also requires labeling of portable, secondary containers under certain conditions; however, it is good chemical hygiene practice to label all laboratory containers/vessels with a chemical name(s) and indication of the hazard(s) of the contents. Label generating functionality is available through ChemWatch.

1.2.4 Other Chemical Information and Safety Data Sheet Resources

Laboratory personnel are also encouraged to review data and information available from other recognized sources, such as government bodies and professional organizations. A sample of these resources is available below.

Agency for Toxic Substances and Disease Registry

American Chemical Society: Chemical Safety Practices and Recommendations

Centers for Disease Control and Prevention: Chemical Safety

Columbia University Research Environmental Health and Safety Handbook

Fisher Scientific: Chemical Safety Information and Safety Data Sheets

Occupational Health & Safety Administration: Laboratory Safety Guidance

Occupational Health & Safety Administration: Occupational Chemical Database

Safety Information Resources Inc. (SIRI): Safety Data Sheets

Sigma-Aldrich: Chemical Safety Information and Safety Data Sheets

VWR International: Chemical Safety Information and Safety Data Sheets

1.2.5 Chemical Exposure Routes

A hazardous chemical's SDS will identify likely routes of exposure (see Section 1.2.2 above). In general, hazardous chemicals can enter the body via inhalation, skin (or eye) absorption, ingestion, and injection.

- **Inhalation**: For most chemicals in vapor, gas, mist, or particulate form, inhalation is the major route of entry. Once inhaled and deposited in lungs, chemicals can cause damage, from simple irritation to serious tissue destruction and/or systemic toxicity.
- **Skin (or eye) absorption**: Dermal or skin contact can cause simple redness and irritation or mild dermatitis to severe damage, up to and including destruction of skin or tissue.
- **Ingestion**: Chemicals that inadvertently get into the mouth and are swallowed may harm the gastrointestinal tract or be absorbed and transported by the blood to internal organs where they can cause damage.
- **Injection**: Substances may enter the body if the skin is penetrated or punctured by contaminated objects. Effects can then occur as the substance is circulated in the blood and deposited in the target organ(s).

Section 1.4 Minimizing and Controlling Chemical Exposure provides important information on reducing exposure to hazardous chemicals in the laboratory.

1.2.6 Toxicology/Health Effects of Chemical Exposure

In order to make informed decisions concerning the protection of personnel from the effects of hazardous substances it is necessary to understand basic concepts of chemical toxicology. Toxicity of a substance can be defined as the relative ability of that substance to cause adverse effects in living organisms. This ability is dependent upon several conditions. The quantity or the dose of a substance determines whether the effects of the chemical are toxic, non-toxic or even beneficial. In addition to dose, other factors influence the toxicity of a substance such as the route of entry, duration and frequency of exposure, combination with other substances or conditions, and inherent variations and susceptibilities between species and within species and individuals.

Understanding the basic concepts of chemical toxicity and the routes by which chemicals enter the human body can help in making critical decisions about the manner in which a hazardous substance should or should not be used. Decisions such as whether a hazardous substance can be substituted with a less hazardous one, or whether it should be used only with an engineering control, such as in a chemical fume hood or glove box, and what PPE is necessary to protect the user from potential exposure, are all informed by a basic understanding of the chemical's toxicity and toxicological properties.

1.2.7 Physical Hazards of Chemicals and the Laboratory Environment

In comparison to toxic effects or other health hazards, chemicals may also pose physical hazards. Chemicals which are classified as physical hazards may cause one or more of the following hazardous effects or possess one of the following properties: explosive; flammable (gases, aerosols, liquids, or solids); oxidizer (liquid, solid or gas); self-reactive; pyrophoric (liquid, solid or gas); self-heating; organic peroxide; corrosive to metal; gas under pressure; or in contact with water emits flammable or toxic gas. Any chemical meeting the criteria of a physical hazard must be handled in accordance with manufacturer's guidance, SDS information and other available resources.

In addition to the physical hazards of chemicals, many laboratory conditions, activities and processes pose physical hazards. Physical hazards of the laboratory environment are those that can cause harm to the body. These include extreme temperatures, ergonomic stresses, noise, particulate matter, electricity, pressure, vacuum, ionizing and non-ionizing radiation, and those resulting from force or direct contact, such as crushing, impact, impingement, entanglement, laceration, puncture, striking, slipping, tripping, and falling. Laboratory personnel must be aware of the physical hazards of all chemicals and those of the laboratory environment, as identified by the LATCH, and utilize engineering and administrative controls and personal protective equipment to control these hazards, as appropriate; see section 1.4.

Note, for information on ionizing radiation, please see the Columbia University Radiation Safety Manual.

1.3 Guidelines for Working with Chemicals

Good laboratory hygiene relies on adherence to protocols, procedures, policies and best practices. Ensuring that proper work practices are followed will limit the probability of occupational exposure to hazardous chemicals, thus reducing the likelihood of injury and illness.

1.3.1 General Housekeeping and Laboratory Hygiene

Disorderly laboratories and unsafe practices contribute to accidents and can hinder emergency response activities. The following general rules must be adhered to in every laboratory:

- Keep all aisles, doorways and emergency exits free from obstruction.
- Keep all emergency equipment including fire extinguishers, fire blankets, overhead emergency showers, eye-face wash/drench hose units, and chemical spill kits free from obstruction.

- Remove gloves and wash hands and arms before leaving the laboratory or handling the telephone, door handle/knob, or other "common" surfaces. Remove lab coat before leaving the laboratory.
- Keep all work areas clean and uncluttered. Chemical containers should be relocated to cabinets or dedicated shelving and not stored on the open bench when not in use. Wipe benches with cleaners or disinfectants regularly.
- Avoid storing chemical containers, particularly glass bottles, on the floor. If floor storage is unavoidable, all chemical containers on the floor must be stored in deep, corrosion-resistant plastic trays and away from high-traffic areas.
- Do not store chemical containers or chemical waste under sinks. Leaks under sinks can compromise containers, and hazardous materials storage can impede maintenance and repair activities.

1.3.2 Food, Beverage, Smoking and Cosmetics Use in the Laboratory

The consumption or storage of food and drink, as well as gum chewing, smoking, and the application of cosmetics, in any laboratory where chemical, biological, or radiological materials are used or stored is strictly prohibited. Note that this prohibition extends to desk and computer areas within laboratories. Handling and changing of contact lenses in a laboratory must also be avoided.

1.3.3 Unattended Work

The unattended operation of laboratory equipment or experiments is strongly discouraged. Unattended work can lead to laboratory accidents and property damage. If unattended work must be performed, the National Research Council's publication, *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards,* recommends that laboratory personnel design these experiments so as to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas. Laboratory lights should be left on, and signs must be posted identifying the nature of the experiment and the hazardous substances in use, in accordance with the University's policy on Unattended Laboratory Operations. Arrangements should be made for other laboratory personnel to periodically inspect the operation. Posted information must include contact information for the responsible individual(s) in the event of an emergency.

1.3.4 Working Alone/Working "Off Hours"

Working with chemicals or performing hazardous operations alone, at night, or otherwise in isolation, places individuals at special risk and should be avoided whenever possible. The PI is responsible for ensuring that employees and students perform only those tasks for which they are qualified by training and experience, especially during off-hours when they may be unsupervised or unaccompanied. PIs must also define for their staff any prohibited activities for laboratory personnel working alone or during off-hours, based on the hazard of the materials used or the activity performed, such as the use of pyrophoric materials. All personnel working alone in the laboratory must hold an applicable FDNY Certificate of Fitness. Personnel working alone or during off-hours are also encouraged to contact Public Safety upon arrival to the laboratory, and to inform Public Safety of their anticipated time of departure, in order to allow for wellness checks. If personnel are planning to work with highly hazardous materials after hours, they are strongly encouraged to implement the buddy system, where one other laboratory member will be present in the laboratory and check on the person doing the experiment periodically.

1.3.5 Requirements for Visitors and Minors

As per the guidelines and information for short term visitors, including minors, short term visitors should complete the "Visitor Registration Form.", Visitors who are minors also must submit the "Minor Visitors Parental Consent Form" prior to the visit. Researchers (including minors) who come to Columbia University to work actively in a laboratory as part of a project, should follow the regulations and requirements set forth by the specific programs that they are associated with. Visitors, other than those who are in laboratories for very brief periods such as for a tour, are expected to comply with the same training requirements as Columbia personnel.

1.3.6 Chemical Storage and Segregation

Proper storage of chemicals in laboratories is a critical safety concern. Improperly stored chemicals could react, resulting in hazardous products or a fire. Follow good storage practices no matter where chemicals are stored (e.g., cabinets, refrigerators, or shelves). Carefully read the SDS and container label before storing a chemical as these will indicate any special storage requirements, as well as incompatibilities. Important information on chemical safety topics can be accessed through EH&S Chemical Safety webpage.

Good Storage Practices

- Chemicals shall be segregated in accordance with good practice and the Columbia University Chemical Segregation and Storage Chart. Avoid storing chemicals alphabetically as this often results in mingling of potentially incompatible hazard classes. Inert chemicals or chemicals within the same hazard class (e.g., inorganic acids, non-halogenated solvents) can be stored alphabetically for ease of retrieval.
- Chemicals should be stored in approved, compatible containers.
- Chemicals should be stored below eye level with heavy objects stored on lower shelves.
- Corrosive chemicals should not be stored on bare metal shelves. Instead, use plastic storage bins or shelves, or cover metal surfaces with protective, plastic-backed paper (e.g., Benchkote) and change frequently.
- When practical, chemicals in the same hazard class should be stored in corrosion-resistant secondary containers.
- DEA controlled substances shall be stored in locked containers as specified in the Policy for the Acquisition, Use, and Disposal of Controlled Substances in Research.

Laboratory Security

- A laboratory security program should be designed to protect laboratories from any intentional misuse or misappropriation of materials. The brochure for chemical security as developed by EH&S is an important resource in understanding important chemical security criteria.
- Within a laboratory, the most obvious form of security is the door lock. Laboratory doors should always be kept closed, and doors with automatic closers should not be held open by external means. Keeping laboratory doors to corridors closed improves security and also helps ensure fire safety, proper functioning of laboratory ventilation systems and in maintaining contaminant-containing pressure differentials between labs and corridors.
- Other possible security measures to consider include card access systems for laboratory doors, video surveillance outside of doors, and/or having a personnel sign-in system before entering shared laboratory spaces.

1.3.7 Hazardous Substance Management Standards and Guidelines

Federal, state and local regulations, as well as University policy, prescribe certain requirements for hazardous substances.

OSHA Regulated Substances

OSHA defines Permissible Exposure Limits (PELs) for several hundred hazardous substances. Additionally, there are numerous OSHA substance-specific standards requiring specific safety programs to reduce exposure to workers who may be exposed to specified chemicals.

OSHA substance-specific standards typically require training of laboratory personnel in safe handling and disposal practices, implementation of engineering controls (e.g., chemical fume hoods), work practices, administrative procedures (e.g., medical surveillance), PPE and other approaches used to reduce exposure and minimize personal risk, procedures for monitoring of airborne concentrations when any PELs* may be exceeded, and communication of monitoring results to employees and retention of monitoring data for a specified time period.

*A PEL may refer to any of the following:

Time Weighted Average (TWA) - the maximum allowable airborne concentration, averaged over an eight-hour workday, to which a person may be legally exposed.

Action Level (AL) - a concentration below the TWA, at which some of the requirements of a substance-specific regulation must take effect.

Ceiling (C) - the airborne concentration of a contaminant that must never be exceeded in the workplace environment. This largely applies to compounds that may be fatal or cause permanent impairment upon even brief exposures, such as carbon monoxide.

Short-Term Exposure Limit (STEL) - the maximum allowable exposure for (typically) a fifteen-minute period. A limited number of excursions over the TWA may be permissible (if they do not exceed the Ceiling value) provided that the day's average exposure is below the TWA.

Formaldehyde/Formalin

Formaldehyde is a potential carcinogen, and its use is strictly regulated by OSHA. To ensure the hazards associated with formaldehyde and formalin use are anticipated, recognized, evaluated, and controlled, and that information concerning these hazards is communicated to affected employees consistent with the OSHA Formaldehyde Standard, a Formaldehyde Exposure Control Policy and Formaldehyde training program have been established. All formaldehyde and formalin users must be familiar with the policy and safe work practice, as well as attend training in accordance with the Policy's requirements.

Pyrophoric Chemicals

Pyrophoric reagents, such as certain organometallic compounds, aluminum alkyls and metal hydrides, are extremely reactive to oxygen and moisture, and ignite spontaneously when exposed to air. Precautions must always be taken to prevent contact with air or water. Despite their inherent hazards, pyrophoric materials can be safely stored and manipulated if proper techniques and precautions are carefully followed. However, the consequences of even the smallest error during the manipulation of these substances can be catastrophic.

Important storage considerations for pyrophoric materials include the following:

- Pyrophoric reagents must be stored in their original containers.
- The original bottle can be stored in a desiccator or in the manufacturer's original outer container (usually a large can).
- Outer containers must be clearly and accurately labeled.
- If applicable, store in a glove box under an inert atmosphere, or consider backfilling the container with inert gas.

The importance of experience and comprehensive knowledge of the correct techniques for using pyrophoric and air-sensitive reagents cannot be overstated. Before working with pyrophoric materials users should consult the relevant safety data sheets (SDSs). Only qualified and experienced laboratory workers should ever manipulate these materials, and only after they have attained a complete understanding of the hazards involved and received hands-on instructions from knowledgeable peers, including "dry" practice runs with non-hazardous materials, regarding correct handling techniques. Additional information regarding the safe handling of pyrophoric materials should be reviewed by all laboratory personnel where such substances are used or stored. EH&S supplies dry sand extinguishing media to all laboratories that use pyrophoric materials. Users must be familiar with the location of the extinguishing media, and its use. Laboratories may contact EH&S to inquire about this service.

Users must implement the use of hazard-specific PPE such as flame-resistant lab-coats (Nomex or Kevlar), and avoid wearing synthetic clothing, when working with pyrophoric materials. As with handling any hazardous chemicals, users must wear proper safety glasses/goggles and should consider the use of face shields when there is a risk of explosion, large splash hazards or a highly exothermic reaction. EH&S recommends the use of flame-resistant gloves such Kevlar or Nomex gloves, over the nitrile gloves, while handling large amounts of pyrophoric materials. All manipulation of liquid or solid pyrophoric materials must be conducted inside an *inert glove box* or *functioning and certified chemical fume hood* with the sash level at the lowest height possible to perform the required operations. Handling pyrophoric materials alone is a dangerous practice and MUST be avoided. Other lab personnel must be present and aware of the operation and emergency procedures. In the event of a fire or life safety emergency, the additional personnel can call for help and assist with rescue.

Hazardous Gases

Laboratory storage or use of hazardous gases must be in accordance with pertinent regulations and University procedures, including the Compressed Gas Manual and its associated attachments. This may include storage in a ventilated enclosure and/or installation or use of leak detection equipment. EH&S must be consulted when hazardous gases are considered for laboratory use. All users of compressed gases must complete annual training via the Rascal course "Safe Management and Use of Compressed Gases" and also be trained by an experienced user on specific handling procedures, as needed.

Some important requirements to be mindful of when handling compressed gas cylinders in the laboratory include:

- Compressed gas cylinders should always be secured upright using a chain or strap connected to a wall or a heavy, immovable object with a solid foundation.
- Compressed gas cylinder valves should be protected by a cap when not being actively used or being transported from one location to another.
- Safety data sheets (SDSs) should be available to users especially if using hazardous gases with properties such as toxicity or flammability.
- Compressed gas cylinders should always be clearly labeled indicating the contents of the cylinders. Empty cylinders should be labeled as empty, to distinguish them from the filled ones.
- Incompatible gases should always be stored away from each other. A distance of 20' should be maintained between flammable and oxidizing gases in the laboratory space, according to FDNY regulations.

Cryogenic Materials

Cryogenic materials such as liquid nitrogen present both a thermal and an oxygen displacement hazard. Laboratories possessing more than 60 gallons (generally two tanks or more) of liquefied cryogenic gases, such as liquid helium or liquid nitrogen, are required to have an oxygen monitor present in the laboratory. Oxygen monitor alarms must always be acknowledged by laboratory personnel and taken seriously as a matter of health and safety. The Policy for Response to Oxygen Sensing Equipment in Laboratories is to be followed during all such responses.

It is essential that laboratory personnel wear appropriate PPE, as specified in the laboratory-specific LATCH, when handling or using cryogenic materials. Cryogenic materials, including dry ice, must only be handled in well-ventilated environments and never used or stored in cold rooms or other non-ventilated spaces.

Particularly Hazardous Substances (PHS)
OSHA has established a category of chemicals known as Particularly Hazardous Substances (PHS) for which additional precautions beyond normal standard operating procedures may be required. Included in the PHS definition are select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity. Laboratory personnel must follow laboratory-specific procedures to avoid exposure to PHSs.

Before these substances are used, laboratory personnel must be fully aware of the risks involved and be fully trained in appropriate storage, handling, and disposal procedures. PHS use and storage must be assigned to designated areas within the laboratory. EH&S can evaluate PHS procedures, prescribe special limitations, necessary equipment and facilities or operating conditions, PPE and additional personnel training requirements, as needed.

Controlled Substances in Research
The acquisition, use and disposal of controlled substances in New York State are strictly regulated by the New York State Department of Health (NYS DOH) Bureau of Narcotic Enforcement and the United States Department of Justice Drug Enforcement Administration (US DEA). These regulations prescribe a variety of administrative and physical controls aimed at preventing diversion of controlled substances. At Columbia University, Principal Investigators are individually responsible for obtaining and maintaining the appropriate license(s) and registration(s) to acquire and use controlled substances. To assist researchers in understanding and meeting their individual obligations under these regulations, Columbia University has established a Policy for the Acquisition, Use and Disposal of Controlled Substances in Research

In addition to the Policy, several Appendices, Resources and Reference Documents have been prepared to assist researchers in navigating the requirements for controlled substances. Training on the use and management of controlled substances is available on RASCAL.

Nanoparticles
Nanomaterials are substances that are manipulated at the atomic or molecular level and have at least one dimension between 1 and 100 nanometers. Research into the health effects of exposure

to engineered nanomaterials is ongoing. Until the health effects of various nanomaterials are more fully characterized, it is recommended that their handling be approached with caution, accompanied by the use of the standard engineering controls, administrative controls, and PPE used for manipulating other hazardous materials in the laboratory setting, and that waste resulting from nanomaterials be managed as hazardous waste. It is further recommended that researchers planning to utilize nanomaterials consult additional guidance through available resources, including the National Institute of Occupational Safety and Health, and that thorough hazard assessments be performed prior to manipulation of nanoparticles.

3-D printing, an increasingly common source of nanoparticle emissions, is also addressed by this section. All 3-D printers purchased for use in a Columbia University space must be processed in the Accounting and Reporting at Columbia (ARC) portal and receive prior approval by EH&S. This enables EH&S to verify that proper emission controls are established, prior to the purchase of a 3-D printer. The Columbia University Purchasing Card (P-Card) may not be used for the purchase of 3-D printers.

EH&S has conducted emissions assessments on various types of 3-D printers in Columbia University locations. Based on these assessments, general guidance for the use of 3-D printers in University spaces includes: installing and using 3-D printers in well ventilated areas, choosing enclosed printers to contain nanoparticle emissions, choosing stock/matrix materials which generate lower emissions, and maintaining good housekeeping in 3-D printing areas. An assessment can be requested by contacting occusafety@columbia.edu.

Additional common sources of nanoparticle emissions in the laboratory environment include synthetic production of nanoparticles (e.g., carbon nanotubes) and laser cutting operations. Laser cutter purchases much also be processed through the ARC system. Each such operation should be assessed for its potential to pose exposure risks, and any such risks should be controlled accordingly.

Batteries

Laboratories that work with rechargeable batteries, whether commercial batteries and/or self-fabricated batteries, in research applications must take special care to address the inherent risks of these devices.

The greatest risk involved in the use and handling of rechargeable batteries, and with lithium-ion batteries specifically, is thermal runaway. Thermal runaway occurs when heat generated from the battery escapes the cell. The separator melts and allows the anode and cathode to mix. When they react, they cause the temperature of the battery to dramatically increase. This phenomenon can ignite the flammable electrolyte solution and cause a fire or other potentially violent reactions. These fires can be especially challenging to extinguish. All users of rechargeable batteries must follow current guidance on safe procurement, handling and storage, charging and disposal, and must be trained in emergency response. EH&S has developed additional information to avoid incidents and ensure proper handling.

1.3.8 Chemical Substitution

The most effective way to reduce the risk of exposure to a hazardous material is to eliminate it entirely from the work environment. This can be accomplished by replacing hazardous materials with safer, less hazardous alternatives capable of performing the same function. EH&S can assist laboratory personnel in evaluating work practices to identify candidates for substitution. The Massachusetts Institute of Technology (MIT) offers a valuable tool for assisting laboratory personnel in choosing safe substitutions for hazardous chemicals and processes. Visit the MIT Green Chemical Alternatives Wizard for more information.

1.3.9 Mercury-Containing Devices

Mercury is a toxic metal, and must be carefully cleaned up if spilled. To minimize exposure to mercury vapors and hazardous waste generated from broken thermometers, EH&S has established a mercury substitution program. Upon request, EH&S will replace a mercury thermometer with an alcohol thermometer, at no cost to the laboratory, with the understanding that the laboratory will order mercury-free thermometers thereafter. A variety of options and temperature ranges are available.

The Mercury Device Registration Program, which is a complement to the mercury thermometer exchange program, will promote improved tracking of mercury-containing devices and allow EH&S to focus its efforts on helping those who absolutely must maintain a mercury device(s), to establish safe storage and handling procedures, prepare them with necessary knowledge about immediate, defensive actions when a mercury release occurs, and ensure EH&S has adequate resources at the ready to assist laboratories in the event of an incident.

1.3.10 Discarding Used Contamination-prone Laboratory Equipment

Prior to disposal of any laboratory equipment, end-users must ensure that equipment is free of any contamination before handling by Facilities Operations or outside contractors. Many items are eligible for expedited Clearance via submission of an email form and photo attachments to verify cleanliness. The equipment Clearance process details the necessary steps.

1.3.11 Vacating Laboratory Space

Research scientists vacating University facilities or relocating within the University are responsible for leaving laboratories in a state suitable for re-occupancy or renovation by following the Procedures for Vacating a Laboratory. EH&S Safety Advisors will assist laboratories in completing the vacating process. Laboratory space must not be re-occupied, and no renovation work should be started until the space has been issued final Clearance by EH&S.

Additional resources, including a comprehensive Laboratory Move Guide, are available to guide laboratory personnel through this process.

1.4 Minimizing and Controlling Chemical Exposure

Occupational hygiene is the science devoted to the anticipation, recognition, evaluation, prevention, and control of environmental factors or stressors arising in or from the workplace which may cause sickness, impaired health and well-being, or significant discomfort among workers. This applies to all workplace hazards, including chemical exposures. Understanding the hazards of chemicals and how exposures can occur is critical to minimizing and controlling exposures. The recognized hierarchy of controls dictates that the elimination of a hazardous substance or its substitution with a less hazardous alternative should be the first approach. If elimination or substitution is not feasible, or does not completely eliminate or adequately reduce a potential hazard, then engineering controls must be implemented to minimize the potential exposure hazard. If a hazard is not effectively managed following the implementation of engineering controls, then administrative and work practice controls must be employed, followed by the careful selection and use of personal protective equipment in accordance with the University's Policy for Personal Protective Equipment in Research Laboratories.

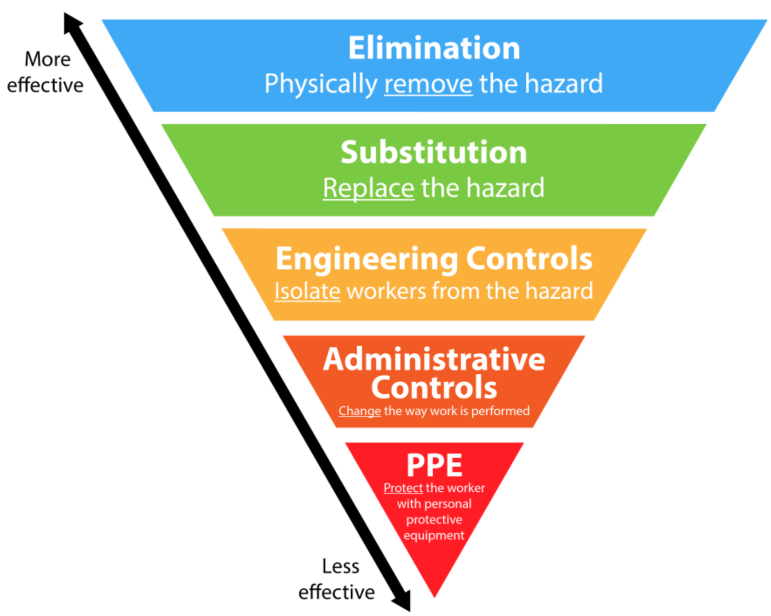

Figure 2: Hierarchy of controls pyramid exhibiting best hazard control methods

1.4.1 Elimination and Substitution

Removing a hazard from the workplace is the most effective method of minimizing exposure. Elimination of a hazardous substance from a process, or substitution of a hazardous substance with a less hazardous alternative should always be the first approach in any attempt to minimize chemical exposure. The American Chemical Society Green Chemistry Institute and the USEPA's Green Chemistry website, as well as the MIT Green Chemical Alternatives Wizard, are examples of resources offering information focused on minimizing the use and generation of hazardous substances.

1.4.2 Engineering Controls

If a chemical hazard cannot be eliminated, the next best strategy for its control is at its source through the use of engineering controls. Engineering controls are devices or actions that automatically isolate or physically limit exposure to a hazard, thereby reducing the risk to personnel. For this reason, engineering controls are often considered the "first line of defense" for reducing exposure to hazardous substances. Engineering controls must only be used as designed and not be modified unless appropriate testing and certification clearly indicates that protection of personnel will be equal to or greater than the original protection afforded by the unmodified control device.

The following is a summary of the most common engineering controls employed in Columbia University research laboratories to control chemical hazards:

General Laboratory Ventilation

Laboratories working with hazardous materials are equipped with fresh air ventilation designed to exhaust from inside the laboratory space to the outside. Laboratory rooms are kept at negative pressure compared to public areas to help avoid contamination of adjacent spaces.

Chemical Fume Hood

A Chemical Fume Hood (CFH) is a device, integrated into the ventilation system of a laboratory, which serves to isolate airborne contaminants from laboratory workers by means of unidirectional, exhausted airflow. Typically considered the primary engineering control for hazardous chemicals in the laboratory, CFHs must be properly used and maintained to afford the user effective containment of hazardous airborne contaminants. For specific information on the proper use and maintenance of CFHs, please refer to the University's Chemical Fume Hood Policy.

The following general guidelines must be observed when using a CFH:

- Use a ducted CFH for work with hazardous gases, volatile or potentially airborne hazardous substances, malodorous chemicals and OSHA Particularly Hazardous Substances, such as acute toxins, carcinogens, mutagens, and reproductive hazards.

- Avoid permanent storage of materials in chemical fume hoods as this may disrupt air flow, creating turbulence and the potential for exposure to airborne hazards. Observe all restrictions based on FDNY or other regulatory requirements.
- Work only within the sash height range certified by EH&S. Containment of airborne hazards cannot be assured outside of this range. Do not use a CFH unless it has been certified within the past twelve months by EH&S, which can be determined by observing the fume hood's certification sticker, typically affixed to the hood in a visible area adjacent to the sash.
- Perform all work at least 6" from the front sill of the fume hood work surface to promote adequate capture of hazardous vapors, dusts and mists.
- A fume hood that is identified as not functioning properly must be reported immediately to Facilities Operations (CUIMC: 305-7367, Morningside: 854-2222 and LDEO: 845-365-8822) as well as EH&S (CUIMC: 305-6780, Morningside/Manhattanville: 854-8749). EH&S will confirm the hood is not functioning and will place an "Out of Service-Do Not Use" sign on the hood. Do not use a CFH that is posted with an "Out of Service-Do Not Use" sign or is otherwise believed to be not functioning properly.
- Tip: Tape a Kim-Wipe to the bottom of the sash to verify the direction and qualitative force of the airflow.

Other Local Exhaust Ventilation

When hazardous chemicals cannot be used in a CFH, extractor arms, "snorkel trunks" or other local ventilation may be needed to minimize exposure. Extractor arms, or trunks, allow for capture and exhaust of hazardous substances close to the source of use, before their release into the laboratory environment. Although not as effective as a CFH due to the relatively higher degree of containment offered by a CFH, these devices, if properly designed and used, can be effective. These devices must be properly designed and installed to ensure adequate contaminant capture and efficacy.

Ventilated hazardous gas cabinets are another type of local exhaust ventilation, in which hazardous gases are stored and used to ensure segregation from the laboratory environment and ventilation of the hazardous gas(es) in the event of a leak.

Glove Box

A glove box is a sealed enclosure designed for the manipulation of high-hazard substances in a safe manner. Glove box interiors are often filled or supplied with inert gas to protect the contents of the glove box from contact with the ambient atmosphere. Built into its sides are gloves to allow the user to perform tasks inside the box without breaking containment. The glove box is usually transparent to allow the user to see the materials being handled within. It is important to avoid wearing hand jewelry, watches or long nails or using sharp objects, such as needles, blades, etc., as they may puncture the gloves and breach containment. It is imperative that users be trained on the proper use of a glove box before manipulating hazardous materials within.

Biosafety Cabinet

Biosafety cabinets (BSC) are the primary engineering control for the minimization of exposure to potentially infectious materials. BSCs combine directional air flow and high efficiency particulate air (HEPA) filters to protect researchers and the environment from aerosolized microorganisms or particulate materials. Ambient air enters the cabinet through an intake grill at the face (where the user sits), preventing contaminants from entering the cabinet. This air is then passed through a HEPA filter before being returned to the work surface, providing a sterile atmosphere. Simultaneously, particulates and droplets generated at the work surface are captured via a separate intake within the cabinet, while air is discharged from the cabinet through a separate HEPA filter, preventing contaminants generated at the work surface from entering the laboratory. HEPA filtration theoretically removes 99.97% of particles with an aerodynamic diameter of 0.3 microns; smaller or larger particles are removed with greater efficiency. **Laboratory personnel should consult the** Columbia University Biosafety Manual **for detailed information on the types and proper use of BSCs.**

1.4.3 Administrative Controls

Chemical labeling (see Section 1.2.4), training (see Section 1.8), laboratory-specific standard operating procedures (SOPs), chemical storage practices, and good housekeeping are the most common administrative controls in academic research laboratories.

The Columbia University Guidelines for Laboratory Design, developed by the Columbia University Laboratory Design Work Group (LDWG), are an additional administrative control for the safe, efficient and consistent design of research laboratories. The Guidelines are primarily intended for the design and construction of new "wet" laboratories or renovations in which significant modifications will be made and where building systems and infrastructure are adaptable to the Guidelines. Although not primarily intended for "dry" or computational laboratories, components of the Guidelines may apply and should be incorporated in the design of these laboratories, where applicable. The Guidelines do not take the place of code requirements or standards but rather serve as a supplement to aid the project team with defining the detail and scope of design. Several appendices are also included in the Guidelines to define the signage, emergency equipment and other laboratory requirements.

Equipment Evaluation and Maintenance

Laboratory and emergency equipment, including hardwired alarms and sensor or detection systems, shall be installed, evaluated and maintained in accordance with regulation, University policy, manufacturer's or other technical specifications, and, where appropriate, recognized industry standards. Refer to the appropriate sections of the device's user manual for equipment specific information.

Work Practices and Standard Operating Procedures (SOPs)
Adhering to proper work practices reduces the chance of occupational exposure to hazardous substances. Laboratory-specific SOPs should be developed by knowledgeable laboratory personnel and reviewed with all laboratory personnel to ensure a thorough understanding of the procedures. Columbia University EH&S provides a template for SOPs available on the website (https://research.columbia.edu/environmental-health-safety-forms). Universities under the UC system have their SOPs available online, and these can be used as examples of SOP templates as well (https://cls.ucla.edu/resources/sop-library). The Safety Rules and Policies noted in *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards* and those listed below can help minimize employee exposure to hazardous chemicals and should be employed in conjunction with laboratory-specific SOPs:

- Attend all required safety training courses.
- Establish and follow SOPs when conducting laboratory work involving hazardous substances or equipment.
    - SOPs should be developed for highly hazardous operations as well as the most frequently performed activities in a laboratory.
- Never eat, drink, chew gum or tobacco, smoke, apply cosmetics, or change contact lenses in the laboratory.
- Select, use and maintain all personal protective equipment in accordance with the University's Policy for Personal Protective Equipment in Research Laboratories and the laboratory's LATCH.
- Store/segregate hazardous materials according to hazard class.
- Report unsafe conditions to a laboratory supervisor, PI and/or EH&S.
- Keep all benches and work areas clean and uncluttered.
- Scale the size of the experiment and use the smallest amount of material that is necessary for the work to be done.
- Remove gloves and wash hands and arms with soap and water after removing gloves and before leaving the work area or handling common items including phones, instruments, doorknobs, etc.
- Properly manage and dispose of all hazardous substances.

1.4.4 Personal Protective Equipment
Personal Protective Equipment (PPE) represents the "last line of defense" against potential exposure to hazardous materials. PPE should never be used as a substitute for proper engineering controls and prudent work practices, but only as an additional measure of protection once all other reasonable precautions have been taken. The University's Policy for Personal

Protective Equipment in Research Laboratories delineates requirements for the selection, use and maintenance of PPE in all laboratories where hazardous substances are stored or used. Personnel should consult their laboratory's LATCH as a baseline for all PPE selection decisions. Appropriate laboratory attire must be worn in conjunction with PPE, including long pants or the equivalent, and closed shoes at all times when present in the laboratory. Synthetic fibers can be flammable and can adhere to skin in the event of a fire; natural fiber clothing is therefore preferred in a laboratory environment.

1.5 Measuring Chemical Exposure

1.5.1 Determination of the Need for Exposure Measurements

The vast majority of chemicals used in research laboratories, when used in research-scale quantities, do not pose a significant health hazard if SOPs and good laboratory hygiene practices are employed. Laboratory staff must not be exposed to OSHA-regulated substances above permissible exposure limits. An exposure assessment, performed by EH&S, is designed to evaluate the chemical(s) used in terms of concentration and quantity, frequency of use, manner in which it is used along with the available engineering controls, in an effort to determine the potential exposure to a user. An exposure assessment will be accompanied by recommendations on methods to reduce exposure, where exposure may exist, and will typically follow the hierarchy of controls (see Section 1.4). The exposure assessment is an important component of the CHP in protecting University employees from potential exposure to hazardous substances.

1.5.2 Exposure Assessment Strategy

EH&S utilizes information from various sources to inform its exposure assessment strategy, including laboratory chemical inventories (see Section 1.2.2), laboratory safety surveys, chemical purchase records, and chemical waste identification. Exposure assessments are carefully planned and coordinated with laboratory personnel to ensure that work activities representative of the exposure potential being assessed are being performed during the assessment. Laboratory hygiene practices will be reviewed and may be qualified and/or quantified with methods such as surface wipe sampling and analysis. Personal and area air sampling/monitoring may be used to quantify the airborne concentration of a hazardous substance, since inhalation is typically the primary route of concern for exposure to volatile hazardous chemicals. Exposure assessments can be requested at any time by laboratory personnel by contacting EH&S or completing the Laboratory Hazard Assessment Questionnaire. Exposure assessments may also be proposed by EH&S based on a laboratory's intended use of a new chemical, a need to confirm the efficacy of a control device, or a combination of other reasons. The results of the assessment will be reviewed and evaluated in comparison to accepted Occupational Exposure Limits (OELs).

1.5.2.1 Reproductive Health Hazard Assessment

The EH&S Occupational Safety program is available to assist members of the Columbia University research community in identifying special research-related risks and discussing potential mitigation strategies for persons who are or who are planning to become pregnant, as well as address concerns related to a partner/spouse of someone planning to become pregnant. A safe laboratory setting should minimize most risks; however, no workplace can eliminate all risks and pregnancy/reproductive health should be factored into one's personal risk assessment, as applicable. More information is available on the Occupational Safety program page.

1.5.3 Frequency of Exposure Measurements

As noted in Section 1.5.2, an initial exposure assessment may include personal air sampling, with samples collected in the employee's breathing zone to represent exposure during a full shift [i.e., 8-hour time weighted average (TWA)] and/or 15-minute Short-Term Exposure Limit (STEL). EH&S will consult with laboratory personnel to determine which groups of employees have potential exposure to establish similar exposure groups (SEGs) so representative exposure samples can be collected.

Depending on the results of the exposure assessment, monitoring may need to be repeated, as required by OSHA or determined by EH&S. An exposure assessment may also be repeated if the laboratory makes a substantive change (e.g., change in chemicals, equipment and/or control measures) to the process under which a prior exposure assessment was performed. If substantive changes do occur, laboratory personnel must contact EH&S for a re-evaluation. Additionally, an exposure assessment may be repeated at the request of an employee or when any employee reports signs or symptoms of exposure. EH&S will advise the laboratory when exposure monitoring can be discontinued.

1.5.4 Notification of Exposure Measurement Results

EH&S will provide a report of the exposure assessment within 15 days of receiving exposure assessment results. If the results are below the accepted OELs, the PI or laboratory supervisor will be notified and asked to post results in the laboratory and/or inform affected employee(s) of the results. If the results are above the accepted OEL, the affected employee(s) and PI and/or laboratory supervisor will be notified and asked to meet with EH&S to discuss the results and next steps, which may include enrollment in a medical surveillance program.

1.6 Medical Surveillance

Columbia University has established a medical surveillance program to address certain workplace hazards, including occupational exposure to biological, chemical and physical hazards. Medical surveillance is intended to provide consultation in case of exposure to hazardous substance(s) above an accepted Occupational Exposure Limit (OEL) and/or if an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory. All required medical examinations and consultations shall be provided to laboratory personnel at no cost, without loss of pay, and at a reasonable time and place.

When a laboratory employee(s) is exposed to an OSHA regulated substance, the laboratory worker shall be required to obtain medical consultation and examination, under the following conditions:

- An employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
- An assessment reveals exposure above the OSHA Action Level (AL), Permissible Exposure Limit (PEL) or Short-term Exposure Limit (STEL).
- An event takes place in the work area such as a spill, leak, explosion, or other occurrence resulting in the likelihood of an exposure above OSHA-defined limits.
- Working with certain biological, chemical, and physical agents including employees who work with patients, laboratory animals, blood borne pathogens, other potentially infectious materials, certain chemicals, or whose work requires the use of a respirator.
- See the Medical Surveillance Policy for further guidance.

The physician or other licensed healthcare professional shall keep written records of all such medical examinations and must maintain these records for the duration of the employee's employment, plus 30 years. Employees shall have access to their medical records in accordance with OSHA's *Access to employee exposure and medical records* standard (29CFR1910.1020).

1.7 Chemical Purchase, Receipt, Inventory and Shipment

1.7.1 Chemical Purchase and Inventory Control

Effective administrative control of laboratory hazards extends to chemical purchasing practices. Laboratories should purchase chemicals in the smallest quantity sufficient for their work. While it is often possible to save money by purchasing materials in bulk, these quantities are usually much more than are necessary for most research laboratories. When these chemicals are stored with no foreseeable use, or to the point that they become degraded, they are considered to be inherently waste-like and must be disposed as hazardous waste.

1.7.2 Chemical Inventory

Each laboratory or laboratory group shall compile and maintain a chemical inventory of all hazardous chemicals normally used or stored in the laboratory. The list shall include relevant information about each chemical, including where it is normally used or stored. This inventory shall be updated as needed, but not less than annually. Refer to your laboratory's LATCH for additional information about chemical inventory requirements.

On the Morningside and Manhattanville campuses, the ChemTracker System is used to maintain inventories of chemicals used by laboratories and is accessible at https://columbia.bioraft.com/. At the Lamont Doherty Earth Observatory (LDEO), laboratories may contact the Safety Office to update or obtain copies of chemical inventory information. At the Columbia University Irving Medical Center (CUIMC) and Nevis, laboratories should follow instructions in the LATCH for preparing a chemical inventory.

1.7.3 Movement/Transport of Chemicals

Movement of hazardous materials within the laboratory or about the campus must receive careful consideration. Secondary containers/totes and/or utility carts must be used whenever hazardous substances are transported. Secondary containers/totes can be made of rubber, metal, or plastic, and should be large enough to hold the contents of the primary container should it break, and must be resistant to reacting with the hazardous material being transported. Secondary containers/totes are available commercially through laboratory equipment suppliers and should be standard laboratory equipment. At the Morningside campus, a limited supply of secondary containers/totes are available on loan from the Biological Stock Room and the ChemStores stockroom. Use both hands when moving chemicals, one under the vessel and the other around the neck of the bottle. Laboratories should consult additional guidance when transporting biological materials between campuses.

Before moving any compressed gas cylinder, ensure that the valve is protected by securing the cap to the cylinder and securely strapping the cylinder to a cart specifically designed for cylinder transport. For long distance cylinder moves or the relocation of a large number of bottles, consult the laboratory's compressed gas vendor for assistance.

The following items and hazardous substances are to be transported via freight elevators only and may not be transported using passenger elevators when a freight elevator is available.

- Animals, animal bedding, and animal equipment;
- Hazardous chemicals and samples, including dry ice;
- Radioactive materials;
- Chemicals in open containers;
- Biological materials and samples;
- Compressed gas cylinders and cryogenic liquids;
- Laboratory items requiring the use of a cart or hand truck.

1.7.4 Shipment of Hazardous Substances

The packaging, documentation and transportation of shipments of Hazardous Materials and/or Dangerous Goods by air, ground, or water is highly regulated by the Federal Aviation Administration (FAA), International Air Transport Association (IATA), United States Department of Transportation (USDOT) and International Maritime Dangerous Goods (IMDG) code. These regulations are aimed at preventing transportation accidents and protecting the public through a variety of administrative and physical controls. These federal regulations also apply to inter-campus transportation and shipments on public roadways. In order to perform any function associated with the transportation of Hazardous Materials or Dangerous Goods, individuals must be trained.

Researchers planning to send a shipment that may contain a hazardous material must first determine the nature of the hazard. EH&S has developed resources for shipping hazardous materials which can be used as a starting point for determining the proper procedures required for shipping a hazardous material, including radioactive materials, infectious substances, or chemicals, and subsequently the steps that should be taken to begin the shipping process. Based on the results of a preliminary classification, researchers may be directed to complete specialized training(s) prior to offering to carriers shipments of certain Dangerous Goods such as dry ice or limited categories of biological materials, or researchers may be required to complete the Intent to Ship Hazardous Materials Form and submit it to EH&S for further instructions and assistance.

1.8 Training and Information

Training is the cornerstone of any successful health and safety program and is a fundamental element of EH&S's commitment to ensuring Columbia University maintains and promotes a safe workplace. Many activities that take place in the course of research, academia and/or clinical care require specialized instruction on how these activities can be conducted safely and with minimal exposure to workplace hazards.

Every member of the University community engaged in laboratory operations is obligated to participate in the University's safety training program. This obligation may be established by a regulatory agency, a condition of a grant, a University policy, a departmental requirement or any combination of these mandates. Safety training course and training frequency requirements can be determined by visiting EH&S's Safety Training webpage.

EH&S provides a wide range of safety training programs, presented in multiple formats and media, which are dynamic, highlighting newly identified hazards, hazard mitigation strategies and regulatory requirements in an effort to maintain pace with the ever-evolving landscape of scientific research. The Laboratory Safety/Chemical Hygiene/Hazardous Waste Management training program is required for all personnel working in a laboratory and/or with chemicals. This course is designed for personnel to develop an understanding of the Columbia University Chemical Hygiene Plan and the laboratory-specific LATCH and establish good laboratory hygiene practices, as well as the basic skills to be able to identify methods for detecting the presence or release of a hazardous chemical and the physical and health hazards of exposure along with effective measures for protecting laboratory personnel, including appropriate work practices, emergency procedures, and PPE selection, use and maintenance.

EH&S provides supplemental information to help keep the Columbia University research community informed about the potential hazards in research laboratories, including EH&S's quarterly newsletter *SafetyMatters*, safety brochures, FDN(wh)Y me?, Lessons Learned Bulletins from incidents and near-miss events, and various other guidance documents.

1.8.1 Principal Investigator Training

The role of Principal Investigator includes unique responsibilities for supporting the health and safety of laboratory personnel, in addition to their research goals. The Rascal course "Principal Investigator Research Safety Responsibilities" (TC6800) is designed to address this aspect of a PI's role and contains information about risk assessment, communication, PPE and other key safety concepts. All PIs are required to complete this course on a one-time basis.

1.9 Recordkeeping

1.9.1 Personal Exposure Monitoring

EH&S shall maintain accurate records of any measurement taken to monitor employee exposures for the duration of employment plus 30 years in accordance with the requirements of OSHA's *Access to employee and medical records standard* (29CFR1910.1020). EH&S shall also keep any results of routine and non-routine personal and/or area monitoring and evaluations of worker exposures to chemicals as a result of accidents, spills, fires, or explosions.

1.9.2 Training Records

All personnel training records are maintained in Rascal, including records of "live" training attendance, provided that attendees record their attendance on the sign-in sheet or other verification mechanism at the time of training.

1.9.3 Medical Surveillance/Consultation Records

The physician or other licensed healthcare professional shall keep written records of all medical examinations and maintain these records for the duration of the employee's employment, plus 30 years.

1.9.4 Availability of Records

Employees shall have access to their medical records in accordance with OSHA's *Access to employee and medical records standard* (29CFR1910.1020).

1.9.5 Availability and Annual Review of the Chemical Hygiene Plan

The University's CHP shall be made available to all laboratory personnel via the University Health & Safety Manual at www.ehs.columbia.edu. The laboratory-specific Laboratory Assessment Tool and Chemical Hygiene Plan (LATCH) shall be made available to all laboratory personnel, on paper, within the individual laboratory for which the LATCH applies.

To determine the effectiveness of the CHP, EH&S's Safety Advisors and laboratory personnel will conduct periodic laboratory inspections to review laboratory safety practices and compliance with CHP requirements. The CHP shall be reviewed and updated by the Chemical Hygiene Officer (CHO) at least annually, or more frequently based on findings, observations and procedural changes.

1.10 Waste Management

Federal, state and local regulations, as well as Columbia University policy, contain procedures for the management of biological, chemical and radioactive wastes. The University's Policy on Drain Disposal of Chemicals, 5Ls of Hazardous Waste Management, Biological Waste Management and Radioactive Waste Management procedures comprise the guidelines laboratory personnel must follow to safely manage waste products from research activities. All laboratory staff should be familiar with the guidelines for biological waste and regulated medical waste, chemical and radioactive waste management and disposal at https://research.columbia.edu/content/hazardous-materials-and-sustainability. Researchers should review these guidelines regularly and utilize the online chemical waste pickup request form and radioactive waste request form for arranging waste removal from the laboratory by EH&S.

Listed below are important waste management recommendations –

- **Waste determination:** A chemical waste is considered a hazardous waste if it is listed as a hazardous waste by state and federal regulations, or exhibits certain hazardous characteristics such as ignitability, corrosiveness, reactivity, and toxicity.
- **Collection of waste:** Hazardous chemical waste should be collected in designated waste containers provided by EH&S. Laboratories can also reuse stock bottles or other containers for waste collection, provided they are in good condition, can be tightly closed and are compatible with the material collected within.
- **Labeling:** Hazardous Waste container labels can be obtained by submitting a request through the chemical waste pickup request form (https://research.columbia.edu/content/hazardous-chemical-waste-management-guidelines) or by contacting EH&S by sending email to labsafety@columbia.edu. Hazardous waste storage containers must be labeled with the names and quantity (percent) of the principal chemical constituents.

- **Segregation of incompatible waste:** Containers must be segregated by hazard class (e.g. acids from bases and flammables).
- **Unbroken chemical container management:** At Morningside campus, EH&S helps with recycling RFID-coded, empty chemical containers. The empty containers (with the exception of acutely toxic, pyrophoric or water reactive chemical containers), can be rinsed with tap water, and then placed in the yellow central receptacles belonging to the Chemical Tracking System (CTS). Empty chemical container disposal/recycling is handled by Facilities on Irving Medical Center and Manhattanville campuses. Any empty containers of acutely toxic (P-listed) chemicals should be treated as hazardous waste and submitted for hazardous waste disposal using the chemical waste pickup form.
- **Glassware recycling**: Contaminated broken or unbroken glassware can be disposed in blue plastic containers that are provided by EH&S. When container is full, submit for pickup using the chemical waste form.

1.11 Emergency Procedures

1.11.1 Chemical Spills

Laboratory personnel must know what procedures to follow in the event of a chemical release. They must know how to report the incident and clean up the spill, if possible. Inappropriate actions or inaction by personnel can delay response activities and worsen the situation. Proper emergency response depends upon knowledge of the chemicals present in the lab. For this reason, laboratories at the Columbia University Irving Medical Center are required to maintain and submit a complete inventory of all the hazardous chemicals in their laboratories. Inventories must be reviewed annually and/or whenever new chemicals are acquired. At the Morningside and Manhattanville campuses, online inventories are maintained centrally through the ChemTracker System.

Chemical spills must be cleaned up promptly, efficiently, and properly. The immediate cleanup of a spill limits exposure to toxic materials, prevents possible slips and falls, and reduces the possibility of fire and explosion.

EH&S classifies spills as either "manageable" or "unmanageable." Manageable spills are spills that do not spread rapidly, do not seriously endanger people or the environment, and can be cleaned up safely by laboratory personnel familiar with the hazardous properties of the chemical, without the assistance of EH&S personnel. All other spills are considered unmanageable, due to their quantity or size, the hazard(s) of the material(s) involved, lack of expertise or equipment to address the release, or a combination of these factors. See the EH&S guidelines for response to chemical spills and explosions for additional information.

Manageable Spills

In the event of a manageable spill, the following procedures must be followed:

- Alert people in the immediate area. Avoid breathing vapors and quickly determine the identity and quantity of the spilled material.
- EH&S must also be notified of any release of any chemicals in the laboratory, even if it is deemed manageable. Telephone numbers to call in case of emergency are posted on telephones in every laboratory and on the "Laboratory" signage at the entrance to each laboratory.
- Consult the Safety Data Sheet (SDS) for hazardous properties and incompatibilities, and don appropriate PPE (such as safety glasses, gloves, and long sleeve lab coat).
- If the spill involves a flammable liquid, turn off all ignition and heat sources.
- Attend to persons contaminated by chemicals by adhering to the instructions in 1.11.3 and 1.11.4.
- Confine the spill to a small area and create a dam around the perimeter. Absorb and neutralize the spill with appropriate material. Use spill kit materials and components appropriate for the spilled material. Collect residue, place in a container, and dispose as hazardous waste through EH&S.
- If the spill involves finely divided solids or oxidizers such as nitrates, permanganates or perchlorates, they must not be allowed to come in contact with combustible materials such as wood and paper or reducing agents. Use wet cleaning methods, a scoop or dustpan and hand broom to collect into a plastic bag. Use an appropriate solvent to clean up residues.
- Clean the spill area with soap and water. Notify the Laboratory Safety Manager, supervisor and/or the Principal Investigator.

Unmanageable Spills

In the event of an unmanageable spill, the following procedure must be followed:

- Do not attempt to clean up unmanageable spills.
- If the spill involves a flammable liquid, turn off ignition and heat sources, if this can be done safely.
- Avoid breathing vapors and leave the spill area immediately.
- Alert people in the immediate area and post warning signs to inform others of the hazard.
- Evacuate personnel and close doors leading to affected areas. Keep personnel away from affected areas until EH&S can evaluate the situation.
- Call EH&S and Public Safety for assistance and notify the Laboratory Safety Manager, supervisor and PI.
- Determine the identity and quantity of material that has been spilled and consult an SDS for hazardous properties, incompatibilities, and other relevant information.
- Attend to persons contaminated by chemicals by adhering to the instructions in 1.11.3 and 1.11.4.

- After-hour spills should be immediately reported to Public Safety, which will contact EH&S for instructions. Be prepared to give the chemical name, volume spilled, location (building and room), and any other pertinent information.
- Ensure a person knowledgeable of the incident remains available to provide information to emergency personnel.

1.11.2 Chemical Spill Kit

All Columbia University laboratories shall have access to a chemical spill control kit, capable of controlling a spill of any hazardous material in the laboratory. A spill kit can be assembled by the laboratory and include an organized collection of absorbent pads, neutralizers, a handheld broom and dustpan and other equipment suitable for addressing manageable laboratory spills. Alternatively, a laboratory can purchase a commercially available spill kit from a laboratory supply company. The goal is for each laboratory to have immediate access to a spill kit for the hazardous substances used or stored in the laboratory. All laboratory personnel must be familiar with the spill kit storage location and use of the spill kit.

1.11.3 Emergency Drench Equipment

Eye-Face Wash/Drench Hose - Laboratories where hazardous substances are used or stored shall be equipped with an eye-face wash/drench hose as detailed in the Columbia University Guidelines for Laboratory Design. The devices are intended to provide a continuous stream of clean, flushing fluid to rinse the eyes or body in the event of a hazardous substance exposure. Laboratory personnel shall perform a weekly test of the eyewash by activating the device and flushing water for a period long enough to verify operation and ensure that clean flushing fluid is available. The location of eyewashes in the laboratory are indicated by a sticker with instruction "Labs must flush weekly" (Figure 2). It is important to know that under ANSI standard for eyewashes, "flushing" constitutes "testing" of the equipment. "Bottled" eyewashes are not appropriate for laboratory use and should be avoided.

A 

B 

Figure 3: A. Eye- Face wash/ Drench hose B. Eyewash label

Overhead Emergency Shower - Laboratories where hazardous substances are used or stored shall be equipped with an overhead emergency shower as detailed in the Columbia University Guidelines for Laboratory Design. The devices are intended to provide a continuous stream of clean, flushing fluid to rinse the body in the event of a hazardous substance exposure. Facilities Operations shall perform an annual test by activating the device for a period long enough to verify operation and ensure that clean flushing fluid is available.

1.11.4 Accidents, Injuries and Medical Emergencies

Accidents, injuries and medical emergencies in and around the laboratory require immediate attention. Such emergencies must be reported immediately to the campus' appropriate emergency contact and the laboratory supervisor and/or PI. All emergencies involving personal injury must be reported using the Columbia University Accident Report Form.

When hazardous substances are involved in an accident, injury, or medical emergency, Public Safety and EH&S must be contacted immediately. Public Safety and EH&S can advise on the best approaches, immediate actions and measures to avoid the spread of, or cross-contamination with hazardous materials. Information about the hazardous substance(s) should be readily available (e.g., name, concentration, quantity, etc.) and a SDS should accompany any injured individual when seeking medical assistance.

EH&S also recommends that departments or PIs provide at least one first aid kit for their lab groups. The supplies should be consistent with the types of injuries anticipated in this research space (such as burns, cuts, fractures, contusions, or allergic reactions). The first aid kits should preferably follow the American National Standards Institute's Minimum Requirements for

Workplace First Aid Kits (ANSI Z308.1-1998) and should be inspected regularly to ensure that no items are missing and that none of the remedies (e.g., saline solution, ointment) in the kit have expired. *Important: First aid kits are not meant as a substitute for seeking medical attention or contacting Public Safety and EH&S in case of an accident or emergency. First aid can be administered as a first response to an injury, or in case of minor cuts and burns.*

1.11.5 Fire

Research laboratories differ from other work environments in that they usually contain a variety of fire hazards. Laboratories are equipped with multi-purpose, dry chemical (ABC) or CO_2 extinguishers, which can be used on all types of fires with the exception of reactive metals, which must use extinguishing agents suitable for the particular metal. Laboratory workers are trained by EH&S in the RACE and PASS procedures. Refer to the Fire Safety Manual for additional information.