



Louisiana State University Chemical Hygiene Plan

**Office of Environmental Health and Safety
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1. PURPOSE AND SCOPE

The purpose of this Plan is to describe the safe and proper use, handling practices, and procedures to be followed by personnel working in University laboratories necessary to protect them from potential health and physical hazards presented by chemicals used in the workplace, and to keep chemical exposures below specified limits. The laboratory safety requirements apply to all faculty, staff, and students engaged in the laboratory use of hazardous chemicals. While the Plan establishes work practices to promote safety in the laboratory, each individual has the first responsibility for ensuring that good health and safety practices are implemented in the laboratory.

Louisiana State University Policy Statement 19 (PS-19), "Environmental Health and Safety", states that all University activities shall be conducted in accordance with applicable safety codes, and governmental safety and environmental standards, including Occupational Safety and Health Administration (OSHA) standards. As such, PS-19 constitutes the basis of the Chemical Hygiene Plan (CHP) which is required by OSHA standard 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories" (the "Laboratory Standard").

2. GENERAL PRINCIPLES

The Chemical Hygiene Plan is a written program which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting personnel from the physical and health hazards presented by hazardous chemicals. The major objectives of the plan are described in Appendix A of the OSHA Laboratory Standard and the National Research Council's publication "Prudent Practices in the Laboratory".

- A. Control all chemical exposures as necessary to protect worker health. General precautions for handling similar groups of laboratory chemicals may be adopted, rather than specific guidelines for particular chemicals. Skin contact with all chemicals should be avoided as a cardinal rule.
- B. Avoid underestimation of risk - Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken. One should assume that any mixture will be more toxic than its most toxic component and that all substances of unknown toxicity are toxic.
- C. Provide adequate ventilation - The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices.
- D. Institute a chemical hygiene program - A mandatory chemical hygiene program designed to control exposures is necessary; and should be a regular, continuing effort; not merely a standby or short term activity. Its recommendations should be followed in academic research and teaching laboratories, as well as by full-time laboratory personnel.
- E. Control chemical exposures below the PELs, TLVs - The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded.

3. GENERAL PROGRAM MANAGEMENT

Each individual is responsible for complying with all LSU, state, and federal rules, regulations, and required procedures; and is held accountable for their actions. If a PI/Supervisor does not take appropriate action to address problems noted during inspection or audits, he or she may be subject to compliance and enforcement action. Issues of non-compliance will be taken to the Department Head

and Dean for action. Deliberate failure to comply which results in serious jeopardy to personnel safety and health or the environment may result in loss of laboratory privileges.

- A. Deans, Directors, and Department Chairs are responsible for maintaining safe operations in their labs on a daily basis. Specific responsibilities include:
 - i. Ensure the Chemical Hygiene Plan is written and followed in their areas.
 - ii. Assure that adequate safety resources are available to laboratory personnel.

- B. Environmental Health and Safety is responsible for providing overall coordination for the Chemical Hygiene Plan (CHP). Specific responsibilities of EHS include:
 - i. Provide initial training for managers, supervisors, and safety coordinators concerning requirements of the program and their responsibilities.
 - ii. Provide guidance for the preparation of procedures, chemical inventories, and training programs required by the CHP.
 - iii. Ensure routine inspections are conducted in the laboratory areas.

- C. The Chemical Hygiene Officer (CHO) is an employee who is qualified by training or experience, to provide technical guidance for the continuing implementation of the CHP. Specific responsibilities of the CHO include:
 - i. Work with administrators and other personnel to develop and implement appropriate chemical hygiene policies and practices.
 - ii. Monitor procurement, use, and disposal of chemicals used in the lab.
 - iii. Maintain current knowledge concerning the legal requirements of regulated substances in the laboratory.
 - iv. Seek ways to improve the CHP.
 - v. Help project directors develop precautions and adequate facilities.
 - vi. Participate in investigation of serious accidents involving hazardous chemicals.

- D. Faculty and Principle Investigators are responsible for maintaining safe operations in their labs on a daily basis. Specific responsibilities include:
 - i. Be familiar with this Chemical Hygiene Plan and ensure that all work is conducted in accordance with requirements of this Plan. They should contact the CHO for advice and assistance regarding this Plan and implementing the provisions of this Plan when needed.
 - ii. Provide written standard operating procedures for specific laboratory procedures.
 - iii. Ensure worker training at the time of initial assignment to the area, whenever a new hazard is introduced to the area or when the employee is reassigned to an area using new or different materials and/or processes.
 - iv. Provide appropriate personal protective equipment and require its proper use and maintenance.
 - v. Ensure an inventory is completed for all chemicals used in their work areas and the information is added to the chemical inventory database.
 - vi. Review and understand SDSs on materials used by personnel under their direct supervision and inform personnel as new SDSs become available.
 - vii. Ensure SDS files are available in the work area and are readily accessible to personnel.
 - viii. Ensure that personnel requests for SDSs and other materials are promptly handled, requesting any necessary information or help from EHS.
 - ix. Ensure that all containers of hazardous materials are labeled with chemical name or trade name.
 - x. Prepare a hazard analysis to identify each hazard, and to assure that protective equipment, procedures and emergency response plans are adequate for each hazard, and for the maximum credible emergency event.

- xi. Plan for accidents and ensure that appropriate supplies are in place and procedures are established for responding to an accident, including cleaning up chemical spills.
 - xii. Monitor the safety performance of the staff to ensure that the required safety equipment, practices and techniques are understood and are being employed and ensure that action is taken to correct work practices that may lead to chemical exposures or releases.
 - xiii. Report all accidents involving an employee's chemical exposure or involving a chemical spill that may constitute a danger of environmental contamination to the Supervisor and EHS. If the spill is significant, also notify LSU Police immediately.
 - xiv. Investigate all chemical accidents and near misses to determine the cause and take appropriate corrective action to prevent similar accidents. Contact the CHO or the EHS Office, when needed, for assistance with investigations, assessment, and recommendations for corrective action.
- E. Employees, staff, students, and visitors working with or around hazardous chemicals in a laboratory responsibilities include the following:
- i. Follow LSU's chemical hygiene procedures and all safety and health standards and rules.
 - ii. Understand and follow all standard operating procedures.
 - iii. Develop good personal hygiene habits.
 - iv. Report all hazardous conditions to the supervisor.
 - v. Wear or use prescribed protective equipment.
 - vi. Refrain from operating equipment without proper training or equipment that has safety defects.
 - vii. Attend and apply training sessions on the Chemical Hygiene Program.
 - viii. Understand the hazards of chemicals they handle and the signs and symptoms of excessive exposure.
 - ix. If an emergency occurs related to an experiment, provide emergency response personnel with information about the conditions that caused the emergency and the existing situation in the laboratory.
4. LABORATORY AND CHEMICAL SECURITY

The Chemical Facility Anti-Terrorism Standards (6 CFR Part 27) and the efforts of the Department of Homeland Security (DHS) has increased the awareness of laboratory and chemical security. DHS has defined specific chemicals as "high risk" and has initiated controls on these chemicals if a facility exceeds a trigger amount. LSU has many of these compounds in levels below the trigger level. While LSU is not required to comply with the formal DHS requirements, it is important to be aware of the need for increased laboratory security. To minimize the theft and improper use of hazardous chemicals including toxic and corrosive substances the following actions should be taken.

- A. Complete a chemical Inventory your laboratory and maintain the inventory in the EHS Assistant chemical inventory data module. Note particularly hazardous substances and particular security risks.
- B. Close and lock laboratory doors when no one is present.
- C. Do not leave hazardous materials unattended at any time when not secured.
- D. Areas where biological agents, radioactive material or particularly hazardous chemicals are stored should be kept secure when not in use.
- E. Restrict access to the laboratory to authorized personnel only and become familiar with these people.
- F. Report any missing inventory to your PI or an EHS Representative.
- G. Prohibit the use of lab space, materials and equipment without the knowledge and approval of the PI.

5. BASIC RULES AND PROCEDURES FOR WORKING WITH CHEMICALS

General Rules are fundamental safety precautions which should be familiar to all lab users and followed at all times

A. Introduction to Standard Operating Procedures

The OSHA Lab Standard identifies eight "elements" that must be included in a Chemical Hygiene Plan. The first of these is Standard Operating Procedures (SOPs) "relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals. [29 CFR 1910.1450 (e)(3)(i)]." This is especially important if your lab operations include the routine use of particularly hazardous substances, i.e., "select carcinogens," reproductive toxins, and substances which have a high degree of acute toxicity [29 CFR 1910.1450 (e)(3)(viii)].

A standard operating procedure (SOP) is a written set of instructions or guidelines that detail the uniform procedures to be followed routinely, and safety precautions to take when carrying out a particular experiment or procedure. The development and implementation of standard operating procedures for critical activities is a core component of promoting excellence in a laboratory and for ensuring a safe, healthy, and environmentally sound workplace. For these reasons, the development of SOPs is an essential administrative tool to be used in the laboratory and is a tool that is required by the OSHA Laboratory Standard.

Each lab needs to have Standard Operating Procedures that are clear, concise, and useful to lab personnel for training and safety purposes. SOP's may be developed according to a process or procedure, to classes of hazardous chemicals, individual hazardous chemicals, or any other reasonable approach that address health and safety concerns of an experimental protocol. SOP's need to be written that address specific processes of the lab. A copy of all SOP's developed must be located in the laboratory spaces and be available to all people in the laboratory. However there are some basic SOP's that are generally applicable to all labs. These general safety procedures are designed to ensure basic levels of personnel health and safety in the laboratory, for routine and common practices, uses, and chemicals.

Standard Operating Procedures for Chemical Safety

B. Basic Information Sources for Handling of Chemicals

Prior to working with chemicals, there are certain steps that must be taken to understand the hazards of the work using chemicals. The primary chemical safety information sources for assessing the hazards of chemical use are Safety Data Sheets (SDSs) and Chemical Container Labels.

i. Safety Data Sheets (SDSs)

In 2013, the OSHA Hazard Communications Standard (29CFR 1910.1200) was modified to reflect the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) format. This change standardized the format of SDS's where hazards are shown using simple symbols and short hazard statements. All personnel working with hazardous materials must have access to SDSs, and be trained in the safe handling of the material. SDSs are documents, prepared by chemical manufacturers, which provide information about the chemical's physical and chemical hazards and recommended exposure limits, and list the means for controlling those hazards. SDSs also provide information about first aid,

emergency procedures, and waste disposal. SDS should be reviewed before beginning work with a chemical to determine proper use and safety precautions.

OSHA has ruled that electronic access to SDSs is an acceptable alternative to maintaining paper files. Each lab, department, or work group has the option to maintain a hard copy SDS binder or file. As a minimum, each should maintain an inventory of hazardous materials names, suppliers, and methods to access the SDS. Please contact the EHS Office if you need assistance in interpreting SDS information.

Safety Data Sheet

ii. Chemical Container Labels

Chemical container labels are a good resource for information on chemical hazards. All containers of hazardous chemicals must have labels attached. Labels on purchased chemicals must include:

1. The common name of the chemical;
2. The name, address and telephone number of the company responsible for the product;
3. Appropriate hazard warnings.

The warning may be a single word (e.g. Danger, Caution, Warning) or may identify the primary hazard both physical (e.g. water reactive, flammable, or explosive) and health (e.g. carcinogen, corrosive or irritant).

Most labels provide additional safety information to help personnel protect themselves from the substance. This information may include protective measures and/or protective clothing to be used, first aid instructions, storage information and emergency procedures.

Laboratory personnel are responsible for:

1. Inspecting incoming containers to be sure that labels are attached and are in good condition and contain the information outlined above.
2. Reading the container label each time a newly purchased chemical is used. It is possible that the manufacturer may have added new hazard information or reformulated the product since the last purchase.
3. Ensuring that chemical container labels are not removed or defaced, except when containers are empty.
4. Labeling any secondary containers used in the laboratory, to prevent unknown chemicals or inadvertent reaction.
5. Verifying that chemical waste containers have complete and accurate chemical waste labels.

Chemical Container Labeling

C. Accidents and Spills.

Chemical spills, releases, and accidents vary considerably in significance. If it is possible for the person involved to clean up the spill or stop the release safely, then it is appropriate for the person to do so. If the spill exceeds the capability of the person involved to control, then leaving the area is the proper response. Notification of spill events is always required.

All personnel should know the emergency procedures.

- i. Eye contact: promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention.
- ii. Ingestion: Consult SDS.
- iii. Skin contact: Flush area and remove contaminated clothing. Consult SDS.
- iv. Clean-up: Promptly clean up spills using appropriate protective apparel and equipment and proper disposal.
- v. All significant accidents should be carefully analyzed with the assistance of EHS and the results distributed to those who might benefit.

Preplanning for and Responding to Hazardous Chemical Spills

D. Avoidance of Routine Exposure.

Each laboratory employee with the training, education and resources provided by supervision, shall develop and implement work habits consistent with this CHP to minimize personal and co-worker exposure to the chemicals in the laboratory. Based on the realization that all chemicals inherently present hazards in certain conditions, exposure to all chemicals shall be minimized.

General precautions which shall be followed for the handling and use of all chemicals include:

- i. Skin contact with all chemicals shall be avoided.
- ii. All personnel shall wash all areas of exposed skin prior to leaving the laboratory.
- iii. Mouth suction for pipetting or starting a siphon is prohibited.
- iv. Eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present shall be prohibited.
- v. Storage, handling and consumption of food or beverages shall not occur in chemical storage areas or refrigerators. Glassware and utensils used for laboratory operations shall not be used for food or drink consumption or preparation.

E. Laboratory Equipment and Glassware.

Each employee shall keep the work area clean and uncluttered. At the completion of each work day or operation, the work area shall be thoroughly cleaned and all equipment properly cleaned and stored.

In addition, the following procedures shall apply to the use of laboratory equipment:

- i. All laboratory equipment shall be used only for its intended purpose.
- ii. All glassware will be handled and stored with care to minimize breakage; all broken glassware will be immediately disposed of in an appropriately labeled broken glass container constructed with corrugated cardboard or other puncture-resistant material.
- iii. All evacuated glass apparatus shall be shielded to contain chemicals and glass fragment
- iv. All laboratory equipment shall be inspected by the user on a periodic basis for safety defects, and replaced or repaired as necessary.

Ground Glass and Glassware Cleaning Safety

F. Laboratory Apparel

A key factor in laboratory safety is the use of personal protection equipment.

- i. Safety glasses meeting ANSI Z87.1 are required for personnel and visitors in laboratories so designated, and will be worn at all time when in the laboratory. Glasses do not provide protection from chemical splashes.

- ii. Chemical goggles and a full face shield (if necessary) shall be worn during chemical transfer and handling operations as procedures dictate.
- iii. Sandals, open toed shoes, and bare feet should be prohibited.
- iv. Lab coats provide adequate body protection for most operations in the laboratory. Laboratory coats will be laundered on a periodic basis (at least monthly). Laboratory coats shall be removed immediately upon discovery of significant contamination.
- v. Appropriate chemical-resistant gloves shall be worn at all times when there may be skin contact with chemicals. The degradation and permeation characteristics of the glove material selected must be appropriate for protection from the hazardous chemical being handled. EHS will provide glove selection information as required. Gloves are to be removed before leaving the work area. Care should be taken not to contaminate working area were gloves are not required by working in the area with gloves is available from the EHS web site.
- vi. Thermal-resistant gloves shall be worn for operations involving the handling of heated materials and cryogenic fluids. Thermal-resistant gloves shall be non-asbestos and shall be replaced when damaged or deteriorated.
- vii. Respirator usage shall comply with LSU's Respiratory Protection Program. If the faculty or principle investigator feels that respirators are needed, the Chemical Hygiene Officer should be contacted for an exposure assessment. Voluntary use of respirators is encouraged where relief from nuisance odors or dust is desirable. A copy of OSHA's statement, "Information for Personnel Using Respirators When Not Required Under the Standard," must be given to those individuals using respirators voluntarily. This statement is an attachment to LSU's program and may be found on EHS's web site.

Personal Protective Equipment for Chemical Exposures

G. Basic Safety Equipment

Every laboratory must have basic safety equipment.

- i. Spill control kits should be on hand to clean up small spills. See EHS website section on "Spills and Accidents" for further guidance and description of a basic spill kit.
- ii. Safety shields should be used where applicable for protection against explosion and splash hazards. Line of sight protection is desirable.
- iii. Fire extinguishers must be available in all laboratories and all personnel shall be trained in their use annually.
- iv. Safety showers are to be available in all laboratories where chemicals are handled. Every laboratory worker should know where the showers are and be trained in its use.
- v. Eyewash fountains must be available in the laboratories to provide a continuous soft stream of water for 15 minutes. The fountains should be located close to the safety showers so that the eyes can be washed while the body is showered if necessary.

H. Personal Work Practices

All personnel shall be alert for unsafe practice and conditions in the laboratory and shall immediately report such practices and/or conditions to the laboratory supervisor. The supervisor must correct unsafe practices and/or conditions promptly.

- i. Long hair and loose-fitting clothing shall be confined close to the body to avoid being caught in moving machine/equipment parts.
- ii. Use only those chemicals appropriate for the ventilation system.
- iii. Avoid unnecessary exposure to all chemicals by any route.
- iv. Do not smell or taste any chemicals

- v. Avoid working alone in the laboratory. When working alone in the laboratory arrange for periodic checks by personnel in adjacent laboratories.
- vi. Avoid practical jokes or other behavior which might confuse, startle, or distract another worker.
- vii. Wash areas of exposed skin well before leaving the laboratory.
- viii. Keep work area clean and uncluttered, with chemicals and equipment being properly stored. Clean up the work area on completion of an operation or at the end of each day.
- ix. Plan your work. Seek information and advice about hazards, plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation.
- x. Use engineering controls. Use the hood for operations which might result in the release of toxic chemical vapors or dust. See section on engineering controls.

General Safety Tips for Working with Hazardous Chemicals

I. General Laboratory Use Policy

Laboratories are usually shared areas and it is the responsibility of all lab personnel to be aware of the activities in the lab.

- i. Sole Occupancy of Building. Under normal circumstances, work should not be done in the laboratory when the only person in the building is the laboratory person performing the work. If necessary, special arrangements need to be made to ensure periodic checks on that person.
- ii. Hazardous Operations. All hazardous operations are to be performed during a time when at least two people are present in the laboratory. At no time shall a laboratory person, while working alone in the laboratory, perform work which is considered hazardous. The determination of hazardous operations shall be made by the laboratory supervisor and/or CHO.
- iii. New Procedures or Chemicals. Prior to the use of new procedures or chemicals, a review of potential hazards created must be undertaken within the department. The review should also be completed when there is a substantial change in the amount of chemicals used or a change in the equipment used in the procedure.
- iv. Unattended Operations. When laboratory operations are performed which will be unattended by laboratory personnel (continuous operations, overnight reactions, etc.), the following procedures will be employed:
 - a. The laboratory supervisor will review work procedures to ensure the safe completion of the operation.
 - b. An appropriate sign will be posted at all entrances to the laboratory.
 - c. The overhead lights in the laboratory will be left on.
 - d. Precautions shall be made for the interruption of utility services during the unattended operation (loss of water pressure, electricity, etc.).
 - e. Containment will be provided in the event of unexpected hazardous material releases.
 - f. Tubing for running water must be in good condition and secured at connections by clamps or wire.

J. Special Procedures for Highly Hazardous Substances.

Special precautions shall be taken when performing laboratory work with any of the following chemical categories: carcinogens, reproductive toxins, substances that have a high degree of acute toxicity, or chemicals whose toxic properties are unknown.

- i. Allow only those persons specifically trained to work with highly hazardous chemicals to work with those chemicals. Designated Area - A hood, glove box, portion of a laboratory, or an entire laboratory must be designated for high hazard use.

- ii. Designated areas shall be posted and their boundaries clearly marked. Posting shall include the identification of the highly hazardous chemicals used in the area. Access to the laboratory should be restricted during high hazard chemical use by the laboratory supervisor.
- iii. Suitable gloves and long sleeves shall be worn during use of high hazardous chemicals.
- iv. Use the smallest amount of chemical that is consistent with the requirements of the work.
- v. Use high-efficiency particulate air (HEPA) filters or high-efficiency scrubber systems to protect vacuum lines and pumps.
- vi. Decontaminate a designated area when work is completed.

6. IDENTIFICATION AND CLASSIFICATION OF HAZARDOUS CHEMICALS

Chemicals have inherent physical, chemical and toxicological properties that require laboratory personnel to have a good understanding of the related health and safety hazards. Determine the specific chemicals you are working with and the type of hazard they present. Many of the substances encountered in the laboratory are known to be toxic or corrosive, or both. Compounds that are explosive and/or are highly flammable pose another significant type of hazard. New and untested substances that may be hazardous are also frequently encountered. Thus, it is essential that all laboratory personnel understand the types of toxicity, recognize the routes of exposure, and are familiar with the major hazard classes of chemicals. The most important single generalization regarding toxicity in chemical research is to treat all compounds as potentially harmful, especially new and unfamiliar materials, and work with them under conditions to minimize exposure by skin contact and inhalation.

The main types of chemical hazards that lab personnel should be aware of are:

- A. Flammability
- B. Corrosively
- C. Reactivity/ Instability
- D. Gases/Cryogenic Liquids
- E. Toxicity

Additionally, compressed gases and cryogenic liquids are often used laboratory materials that present unique hazards.

Below is brief discussion of these major classes of hazardous chemicals.

A. Flammable and Combustible Liquids

Flammable and combustible materials are a common laboratory hazard. Always consider the risk of fire when planning laboratory operations. Flammable and combustible liquids are classified according to their flash point, with flammable liquids having a flash point of less than 100 °F and combustible liquids having a flash point between 100-200 °F. Both flammable and combustible liquids are considered fire hazards.

A fire requires an ignition source, a fuel, and an oxidizer. Eliminating ignition sources from area where flammable substances are handled. Avoid the combined presence of fuel and an oxidizer. Control, contain, and minimize the amount of fuels and oxidizers. Keep fuel sources in closed vessels. Although all flammable substances should be handled prudently, the extreme flammability of some materials requires additional precautions. Consider using inert gases to blanket or purge vessels containing flammable liquids.

Working with Flammable and Combustible Liquids.

B. Corrosive Substances

Corrosive substances cause destruction of, or alterations in, living tissue by chemical action at the site of contact. Major classes of corrosive substances include strong acids (e.g., sulfuric, nitric, hydrochloric, and hydrofluoric acids), strong bases (sodium hydroxide, potassium hydroxide, and ammonium hydroxide), dehydrating agents (sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide), and oxidizing agents (hydrogen peroxide, chlorine, and bromine). Symptoms of exposure for inhalation include a burning sensation, coughing, wheezing, laryngitis, shortness of breath, nausea, and vomiting. For eyes, symptoms include pain, blood shot eyes, tearing, and blurring of vision. For skin, symptoms may include reddening, pain, inflammation, bleeding, blistering and burns. As a physical hazard, corrosive substances may corrode materials they come in contact with and may be highly reactive with other substances. It is important to review information regarding materials they corrode, and their reactivity with other substances, as well as information on health effects.

Working with Corrosive Materials

Special attention should be given for safely using, storing, and disposing of Hydrofluoric acid. Hydrofluoric acid, known as HF, is an extremely corrosive acid used for many purposes including mineral digestion, surface cleaning, etching and biological staining. HF's unique properties make it significantly more hazardous than many of the other acids used in laboratories.

Hydrofluoric Acid Use

C. Highly Reactive/ Unstable Materials

Highly reactive or unstable materials are those that have the potential to vigorously polymerize, decompose, condense, or become self-reactive under conditions of shock, pressure, temperature, light, or contact with another material. Examples of highly reactive chemicals are peroxides, water-reactives, and pyrophorics.

Light, mechanical shock, heat, and certain catalysts can be initiators of explosive reactions. Examples of shock-sensitive materials include many acetylides, azides, organic nitrates, nitro compounds, azo compounds, perchlorates, and peroxides. Acids, bases, and other substances may catalyze explosive polymerizations. The catalytic effect of metallic contamination leads to explosive situations.

Many highly reactive chemicals polymerize vigorously, decompose, condense, or become self-reactive. The improper handling of these materials may result in a runaway reaction that could become violent. Highly reactive chemicals lead to reactions with rates that increase rapidly as the temperature increases. If the heat evolved is not dissipated, the reaction rate increases until an explosion results.

Large-scale reactions with organometallic reagents and reactions that produce flammables as products or are carried out in flammable solvents require special attention. Active metals, such as sodium, lithium, potassium, calcium, and finely divided magnesium are serious fire and explosion risks because of their reactivity with water, alcohols, and other compounds or solutions containing acidic hydrogens. These materials require special storage, handling, and disposal procedures.

Oxidizing agents may react violently when they come in contact with reducing materials, trace metals, and sometimes ordinary combustibles. These compounds include the halogens, oxyhalogens, peroxyhalogens, permanganates, nitrates, chromates, and persulfates, as well as peroxides. Perchloric acid and nitric acid are powerful oxidizing agents with organic compounds and other reducing agents. Perchlorate salts can be explosive and should be treated as potentially hazardous compounds.

Organic peroxides are a special class of compounds with unusually low stability that makes them among the most hazardous substances commonly handled in laboratories, especially as initiators for free-radical reactions. Although they are low-power explosives, they are hazardous because of their extreme sensitivity to shock, sparks, and other forms of accidental detonation.

Certain common laboratory chemicals form peroxides on exposure to oxygen in air. Over time, some chemicals continue to build peroxides to potentially dangerous levels, whereas others accumulate a relatively low equilibrium concentration of peroxide, which becomes dangerous only after being concentrated by evaporation or distillation. The peroxide becomes concentrated because it is less volatile than the parent chemical.

Any sample of a highly reactive material may be dangerous. The greatest risk is due to the remarkably high rate of a detonation reaction rather than the total energy released. A high-order explosion of even milligram quantities can drive small fragments of glass or other matter deep into the body. It is important to use minimum amounts of hazardous materials with adequate shielding and personal protection.

Working with Highly Reactive/Unstable Materials

D. Gases/Cryogenic Liquids

Compressed gases and cryogenic liquids are similar in that they can create pressure hazards and can also create health hazardous and/or flammable atmospheres. One special property of compressed gases and cryogenic liquids is that they undergo substantial volume expansion when released to air, potentially depleting workplace oxygen content to hazardous levels.

A compressed gas is defined as a material in a container with an absolute pressure greater than 276 kPa, or 40 psi at 21 °C or an absolute pressure greater than 717 kPa (104 psi) at 54 °C, or both, or any liquid flammable material having a Reid vapor pressure greater than 276 kPa (40 psi) at 38 °C. The U.S. Department of Transportation (DOT) has established codes that specify the materials to be used for the construction and the capacities, test procedures, and service pressures of the cylinders in which compressed gases are transported. Prudent procedures for the use of compressed gas cylinders in the laboratory include attention to appropriate purchase, especially selecting the smallest cylinder compatible with the need, as well as proper transportation and storage, identification of contents, handling and use, and marking and return of the empty cylinder to the company from which it was purchased

Cryogenic liquids are materials with boiling points of less than -73 °C (-100 °F). Liquid nitrogen, helium, argon, and slush mixtures of dry ice with isopropyl alcohol are the materials most commonly used in cold traps to condense volatile vapors from a gas or vapor stream. In addition, oxygen, hydrogen, and helium are often used in the liquid state. The primary hazards of cryogenic liquids are frostbite, asphyxiation, fire or explosion, pressure buildup (either slowly or due to rapid conversion of the liquid to the gaseous state), and embrittlement of structural

materials. The extreme cold of cryogenic liquids requires special care in their use. The vapor that boils off from a liquid can cause the same problems as the liquid itself.

Working with Compressed Gas

E. Particularly Hazardous Substances

The OSHA Laboratory Standard defines a hazardous chemical as "a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed personnel. The term 'health hazard' includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes". Highly flammable and explosive substances comprise a category of hazardous chemicals.

i. Carcinogen

Carcinogens are chemical or physical agents that cause cancer. Carcinogens are defined as known or suspected carcinogens in the latest edition of the National Toxicology Program's "Carcinogens Summary". Generally they are chronically toxic substances which cause damage after repeated or long-duration exposure. Their effects may only become evident after a long latency period and are particularly insidious because they may have no immediate apparent harmful effects. For a large number of compounds there is limited evidence of carcinogenicity to animals from studies involving experimental animals. Certain select carcinogens are classified as "particularly hazardous substances" because there is evidence from human studies that exposure can cause cancer. These compounds should be handled using the general procedures for work with hazardous substances.

ii. Toxic and Highly Toxic Agents

Acute Toxicity Chemicals are any substance for which the LD50 data described in the applicable SDS (or other literature source) causes the substance to be classified as a level 3 or 4 health hazard according to the HMIS system. It is important to note that the above classification does not take into consideration chronic toxicity (carcinogenicity and reproductive toxicity). Also, note that LD50 values vary significantly between different species, and the human toxicity for a substance may be greater or less than that measured in test animals. OSHA considers substances that are either toxic or highly toxic, as defined above, to be particularly hazardous substances. In evaluating the hazards associated with work with toxic substances, it is important to note that a number of factors influence the response of individuals to exposure to toxic compounds. For example, people are rarely exposed to a single biologically active substance. With this point in mind, it is noteworthy that one toxin can influence the effect of a second. This underscores the importance of maintaining good laboratory practices at all times, and with all chemicals.

iii. Compounds with a High Degree of Acute Toxicity

Compounds that have a high degree of acute toxicity comprise a third category of particularly hazardous substances as defined by the OSHA Laboratory Standard. Acutely toxic agents include certain corrosive compounds, irritants, sensitizers (allergens), hepatotoxins, nephrotoxins, and neurotoxins, agents that act on the hematopoietic systems and agents which damage the lungs, skins, eyes, or mucous membranes. Substances that have a high degree of acute toxicity are interpreted by OSHA as being substances that "may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration".

- iv. **Reproductive and Developmental Toxins**

Reproductive toxins can affect the reproductive health of both male and female personnel and students if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus; these effects include embryo lethality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. Examples of embryotoxins include thalidomide and certain antibiotics such as tetracycline. Women of childbearing potential should note that embryotoxins have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin (e.g., formamide). Pregnant women and women intending to become pregnant should consult with their laboratory supervisor and EHS before working with substances that are suspected to be reproductive toxins.
- v. **Irritants**

Irritants are defined as non-corrosive chemicals that cause reversible inflammatory effects on living tissue by chemical action at the site of contact. A wide variety of organic and inorganic compounds, including many chemicals that are in a powder or crystalline form, are irritants and consequently, skin contact with all laboratory chemicals should always be avoided.
- vi. **Sensitizers**

A sensitizer (allergen) is a substance that causes exposed people to develop an allergic reaction in normal tissue after repeated exposure to the substance. Examples of allergens include diazomethane, chromium, nickel, formaldehyde, isocyanates, arylhydrazines, benzylic and allylic halides, and many phenol derivatives.
- vii. **Hazardous Substances with Toxic Effects on Specific Organs**

Substances included in this category include (a) hepatotoxins (substances that produce liver damage such as nitrosamines and carbon tetrachloride); (b) nephrotoxins (agents causing damage to the kidneys such as certain halogenated hydrocarbons); (c) neurotoxins (substances which produce their primary toxic effects on the nervous system such as mercury, acrylamide, and carbon disulfide); (d) agents which act on the hematopoietic system (such as carbon monoxide and cyanides which decrease hemoglobin function and deprive the body tissues of oxygen); and (e) agents which damage lung tissue such as asbestos and silica.
- viii. **Nanomaterials**

A nanoparticle is collection of tens to thousands of atoms approximately 1 to 100 nanometers in diameter. Nanoparticles that are naturally occurring (e.g., volcanic ash, forest fires) or are the incidental byproducts of combustion processes (e.g., welding, diesel engines) are usually physically and chemically heterogeneous and often termed ultrafine particles. Engineered nanoparticles are intentionally produced and designed with very specific properties related to shape, size, surface properties and chemistry. These properties are reflected in aerosols, colloids, or powders. Engineered nanoparticles may be bought via commercial vendors or generated via experimental procedures by researchers in the laboratory. Examples of engineered nanomaterials include: carbon buckeyballs or fullerenes; carbon nanotubes; metal oxide nanoparticles (e.g., titanium dioxide); quantum dots, among many others. The health effects of exposures to nanomaterials are not fully understood at this time. Until more definitive findings are made regarding the potential health risks of handling nanomaterials, researchers planning to work with nanomaterials must implement a combination of

engineering controls, work practices, and personal protective equipment to minimize potential exposures to themselves and other.

7. HOUSEKEEPING

Only trained and qualified personnel shall be allowed to work in a laboratory at LSU. Each laboratory worker is directly responsible for the cleanliness of his or her workspace, and jointly responsible for common areas of the laboratory. Laboratory management shall insist on the maintenance of housekeeping standards. Supervisors are responsible for ensuring that personnel are trained to work safely in a laboratory. All laboratory personnel are responsible for reading and understanding this procedure.

The following procedures apply to housekeeping standards of the laboratory:

- A. A cleaning routine should be established for the work area with daily and weekly cleaning schedules in addition to a thorough cleaning once a month.
- B. Keep the area as clean as the work allows. Work surfaces should be kept as clean as possible, with only those items needed for the immediate project on that surface.
- C. Clean all working surfaces at the end of each day.
- D. All apparatus(s) shall be thoroughly cleaned and returned to storage upon completion of usage.
- E. Keep floors clean and free of tripping hazards.
- F. Chemical containers shall be clean, properly labeled and returned to storage upon completion of usage. Labels shall face front. Store flammable liquids in a flammable liquids cabinet. Do not store acids above shoulder height or in unprotected metal cabinets. Store water reactive materials away from water sources, such as sprinkler systems and sinks.
- G. When storing items on shelves, the top of the items should be greater than 18" from the ceiling to ensure adequate coverage by sprinkler heads in the event of a fire.
- H. Shelves should be equipped with doors or lips to prevent items from falling.
- I. Keep an adequately stocked spill kit in the work area. Clean up all small spills immediately. Know what to do in the event of a hazardous material spill and take appropriate action immediately.
- J. Do not let stored items project beyond the front of shelves or counter tops. Restrain material stored near aisles, when necessary, to prevent them from falling. Always restrain compressed gas cylinders.
- K. Keep stairways, hallways, passageways/aisles and access to emergency exits dry and free of obstruction.
- L. Store items so they do not block access to the fire extinguisher(s), safety equipment, electric panel boxes, or other emergency items such as an eyewash or safety shower.
- M. Do not allow combustible material such as paper, cardboard boxes, or pallets to accumulate. Do not place these materials in hallways. Set up a process for immediate disposal or filing of items.
- N. Do not let materials accumulate. Ensure materials, chemicals, and equipment that are no longer needed, are disposed of properly or turned in as excess. Know how to manage laboratory wastes properly.
- O. Do not let materials accumulate in laboratory hoods. The safety of this workspace and the ventilation provided is compromised when excessive chemicals and equipment are kept in this space.
- P. Ensure that proper collection containers for biohazards, sharps, and paper trash are placed near the point of use and are adequate of size.
- Q. Do not over fill collection receptacles.
- R. Ensure that all wastes that are not general refuse (e.g., radioactive, chemical, and biohazardous wastes) are prominently labeled and that custodial staff are trained not to remove these materials from the lab.

- S. Faculty and principle investigators should informally conduct housekeeping and chemical hygiene inspections continually.

Housekeeping in Laboratory

6. LABORATORY INSPECTIONS AND AUDITS, COMPLIANCE AND ENFORCEMENT

The Office of Environmental Health and Safety (EHS) has implemented a framework for conducting laboratory/work space inspections and audits to determine laboratory/work space-specific compliance with environment, health, and safety policies, laws, and regulations. The EHS inspections examine a broad spectrum of areas including postings, documentation and training, safety equipment, laboratory/shop protocol, and waste handling. The purpose of the inspection and audit system is to assist the Institute and laboratories in maintaining a safe work and study environment, ensuring compliance with regulations, identifying the locations where training or retraining is needed, and to fulfill LSU's commitment to environment, health and safety stewardship.

A. Internal Inspections

The Office of Environmental Health and Safety has developed a program of laboratory self-assessments to be done at the beginning of each semester. The purpose of these inspections is to promote laboratory safety awareness and internal corrective actions. The Quick Assessment Forms (QAF) are to be done in the spring and fall semesters and forwarded to EHS upon completion of the corrective actions. The QAF will be used as the first step in the accreditation program described below. The link to the form is below. BSL 1, 2 and 3 labs should go to the Biological Safety web page for their specific audit forms.

LSU Laboratory Quick Assessment Form

B. Formal EHS Accreditation

The Office of Environmental Health and Safety has developed a formal Laboratory Accreditation Program. The purpose of the accreditation audit is to ensure that laboratories are safe and complying with environmental regulations. Audits will be conducted by EHS and a formal report will be generated and sent to the PI and the department chair. After any deficiencies are resolved, the PI will receive LSU Safety Accreditation for his laboratories. Additional details of the process can be seen on the links below along with a copy of the audit form and a PowerPoint presentation describing how to get ready for the accreditation audit. A final report will be forwarded to Department management and the Director of EHS. Re-accreditation audits will be scheduled through Departmental Management with the goal of reviewing each laboratory every three years.

LSU Laboratory Audit and Accreditation Procedure

C. Compliance and Enforcement

Each individual at the Institute is responsible for complying with all LSU, state, and federal rules, regulations, and required procedures; and is held accountable for their actions. If a PI/Supervisor does not take appropriate action to address problems noted during inspection or audits, he or she may be subject to compliance and enforcement action. Issues of non-compliance will be taken to the Department Head and respective Dean for recommendations regarding disciplinary action.

Deliberate failure to comply that result in serious jeopardy to personnel safety and health or the environment may result in loss of laboratory privileges.

7. CHEMICAL PROCUREMENT, DISTRIBUTION, AND STORAGE

A. Procurement.

- i. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved.
- ii. No container should be accepted without an adequate identifying label.
- iii. All substances should be received in a central location.
- iv. EHS has implemented an internet based Chemical Inventory Management System. It is the responsibility of each lab to maintain the inventory by adding compounds upon receipt and deleting compound when gone. The system runs on commercial software that contains the chemical inventory module, training module, and corresponding web access packages. The system stores chemical inventory data under a lab owner and allows personnel tracking. This enables EHS to provide support to the organization and emergency personnel in the event of an emergency. The system also promotes waste reduction by identifying excess chemicals for other departments prior to purchase. The software has the ability to track waste, lab equipment, and inspections. The training module allows on-line safety training and documents completion of the training.

Chemical Inventory Management System

Chemical Inventory Management System Training Manual

B. Stockrooms/storerooms.

- i. Toxic substances should be segregated in a well-defined area with local exhaust ventilation.
- ii. Chemicals which are highly toxic or other chemicals whose containers have been opened should be in unbreakable secondary containers.
- iii. Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity.
- iv. Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person.

C. Distribution.

- i. When chemicals are hand carried, the container should be placed in an outside container.
- ii. Freight-only elevators should be used if possible.

D. Laboratory storage.

- i. Amounts permitted should be as small as practical.
- ii. Storage on bench tops and hoods is inadvisable. If hoods are used for storage, they must be labeled as such and not used for experiments.
- iii. Exposure to heat or direct sunlight should be avoided.
- iv. Periodic inventories should be conducted, with the items being discarded or returned to the storeroom/stockroom.
- v. All labels shall face front.

General Guidelines for Chemical Storage

8. ENVIRONMENTAL MONITORING.

In the event of concern about the performance of a hood, when a new hood is put into service, or there is reason to suspect exposure to laboratory personnel, contact EHS to arrange for monitoring and sampling. This may be desirable when highly toxic or very volatile toxic chemicals are used or stored regularly.

9. RECORDS

Accident reports for any safety related incident are to be submitted to Risk Management and Environmental Health and Safety.

10. SIGNS AND LABELS

- A. Prominent signs and labels of the following types should be posted:
- Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory personnel.
 - Locations signs for safety showers, eyewash stations, other safety and first aid equipment, exits and areas where food and beverage consumption and storage are permitted.
 - Warning at areas or equipment where special or unusual hazards exist.

Door Posting for Emergency Purposes

- B. All chemical containers (including waste receptacles) are to be labeled.
- Labeling is important for safe management of chemicals, preventing accidental misuse, inadvertent mixing of incompatible chemicals, and facilitating proper chemical storage. Proper labeling helps assure quick response in the event of an accident, such as a chemical spill or chemical exposure incident. Finally, proper labeling prevents the high costs associated with disposal of “unknown” chemicals.
 - All containers of chemicals being used or generated in LSU research and teaching laboratories must be labeled sufficiently to indicate contents of the container. On original containers, the label should not be removed or defaced in any way until the container is emptied of its original contents. Incoming containers should be inspected to make sure the label is in good condition. It is also advisable to put a date on new chemicals when they are received in the lab, and to put a date on containers of chemicals generated in the lab and the initials of the responsible person.
 - Abbreviations or other acronyms may be used to label containers of chemicals generated in the lab, as long as all personnel working in the lab understand the meaning of the label or know the location of information, such as a lab notebook, or log sheet that contains the code associated with content information. In addition, small containers, such as vials and test tubes, can be labeled as a group by labeling the outer container (e.g., rack or box). Alternatively, a placard can be used to label the storage location for small containers (e.g., shelf, refrigerator, etc.).
 - Containers of practically non-toxic and relatively harmless chemicals must also be labeled with content information, including containers such as squirt bottles containing water.

Chemical Container Labeling

11. INFORMATION AND TRAINING PROGRAM

A. Basic Chemical and Laboratory Training.

- i. Web Based Training Package is provided in conjunction with the EHS Assistant database. Training is required for all laboratory personnel to meet the regulatory based training requirements and consists of five modules (Emergency Response, Hazardous Waste Training, Basic Lab Safety, Hazard Communication, and Cylinder Handling). Each training course and must be completed on a yearly basis.

Online Laboratory Safety Training

B. Training Organization.

- i. In order to provide specific and effective information to all laboratory users in a timely manner, training for the CHP will employ the "train the trainer" system. EHS will provide information and training for managers, supervisors, and safety coordinators for each area. The safety coordinator and lab supervisor of each area will then be responsible for implementing and customizing training for their laboratory users.

C. Training Timing and Frequency.

Information and training shall be provided to laboratory personnel on the following basis:

- i. Initially, all laboratory personnel shall complete a training program.
- ii. Individuals who are assigned to use new hazardous chemicals and/or new laboratory work procedures must have their training upgraded.
- iii. New personnel shall complete a training program.
- iv. All personnel shall be provided with updated information on an annual basis.

D. Training Components.

This training shall include methods of detecting the presence of hazardous chemicals, physical and health hazards of chemicals in the lab, and measure personnel can take to protect themselves from these hazards. The training shall present the details of the Chemical Hygiene Plan and shall include:

- i. The contents of the Chemical Hygiene Plan.
- ii. The location and availability of the Chemical Hygiene Plan.
- iii. The permissible exposure limits for OSHA regulated substances or recommended exposure values for other hazardous chemicals not regulated by OSHA which are present in the laboratory.
- iv. The physical and health hazards of chemicals in the work area.
- v. Signs and symptoms associated with exposure to the chemicals present in the laboratory.
- vi. Location, availability, and how to use reference material on chemical hygiene including Material Safety Data Sheets.
- vii. The criteria for selection and use of personal protective equipment and the limits of its protection.
- viii. Emergency procedures and the location of emergency equipment

E. Training Documentation.

The PI and lab supervisors are responsible for documenting employee training. EHS will maintain records of training provided by their instructors.

12. WASTE DISPOSAL PROGRAM

All chemicals shall be disposed of in accordance with the LSU Hazardous Waste Disposal Program, the details of which can be found on the EHS web site.

The hazardous chemical waste program is designed to provide a simple and convenient way for disposal of chemical waste. Do not dispose of hazardous waste in the trash, down drains, or evaporate in fume hoods.

- A. Provide a secondary container for waste collection containers. Do not accumulate more than 10 gallons of waste in the laboratory.
- B. Keep waste containers closed at all times except when adding or removing waste. Do not leave funnels in containers.
- C. Label all chemical containers with the name of their contents. Include your name, phone number, and department on the label.
- D. Segregate containers by hazardous class. (i.e. Flammable, Corrosive, Reactive, etc.) Do not mix waste streams.
- E. Position containers so that waste labels are visible.
- F. Maintain ten percent free space in waste containers to allow for expansion.
- G. Attend and document annual training for all persons generating hazardous wastes.
- H. Conduct weekly inspections of hazardous waste collection area and maintain an inspection log.
- I. Maintain emergency equipment (eyewash, showers, etc.) and know what to do in the event of a chemical spill, fire, or explosion.
- J. Post the name and phone numbers for responsible persons to contact 24-hours a day in case of an emergency.
- K. When ready for waste pick up; fill out "Waste Pickup Request" in the EHS Assistant and package waste for collection. Do not store waste longer than it can be safely stored. Request collection in a timely manner

13. ENGINEERING CONTROLS

- A. Intent.
The engineering controls installed in the laboratory are intended to minimize employee exposure to chemical and physical hazards in the workplace. These controls must be maintained in proper working order for this goal to be realized.
- B. Modification.
No modification of engineering controls will occur unless testing indicates that worker protection will continue to be adequate.
- C. Improper Function.
Improper function of engineering controls must be reported to Facility Services or EHS immediately. The system shall be taken out of service until proper repairs have been executed.
- D. Usage
 - i. Laboratory Fume Hoods.
The laboratory hoods shall be utilized for all chemical procedures which might result in release of hazardous chemical vapors or dust. As a general rule, the hood shall be used for all chemical procedures involving substances which are appreciably volatile and have a permissible exposure limit (PEL) less than 100ppm or are flammable materials. The following work practices shall apply to the use of hoods:
 - a. Confirm adequate hood ventilation performance prior to opening chemical containers inside the hood. An inward flow of air can be confirmed by holding a thin strip of tissue at the face of the hood and observing the movement of the paper.
 - b. Keep the sash of the hood at or below the indicated maximum operating height except when adjustments within the hood are being made. At these times, maintain the sash height as low as possible.
 - c. Storage of chemicals and equipment inside the hood shall be kept to a minimum.
 - d. Minimize interference with the inward flow of air into the hood.
 - e. Locate apparatus toward the rear of the hood to prevent vapors from escaping.

- f. Leave the hood operating when it is not in active use if hazardous chemicals are contained inside the hood or if it is uncertain whether adequate general laboratory ventilation will be maintained when the hood is non-operational.
 - g. The hood shall not be used as a means of disposal for volatile chemicals.
 - h. The ventilation system shall be inspected annually by EHS. The hood face velocity shall be at least 80-85 feet per minute. A record of each inspection shall be maintained by the Chemical Hygiene Officer.
- ii. Gloves Boxes and Isolation Rooms. The exhaust air from a glove box or isolation room will pass through scrubbers or other treatment before release into the regular exhaust system.
 - iii. Flammable Storage Cabinets. Cabinets designed for the safe storage of flammable chemicals can only do so if used and maintained properly. Cabinets are generally made of double-walled construction and are made of 18 gage steel. The doors are two inches above the base of the cabinet is liquid proof to that point. Two vents are provided on opposite side of the cabinet and are equipped with flame-arrester screens. Always read the manufacturer's information and follow prudent safety practices such as:
 - a. Store only compatible materials inside the cabinet.
 - b. Store chemicals of similar vapor density together when using mechanical ventilation (e.g., heavier than air vapors are vented through the bottom vent and lighter than air vapors through the top vent).
 - c. Do not store paper or cardboard inside cabinets with the chemicals.
 - d. Do not overload the cabinet.