Laboratory Safety Manual

CASE WESTERN RESERVE UNIVERSITY

This document has been prepared by the Environmental Health and Safety Department and reviewed and approved by the Laboratory Safety Committee on

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29 CFR 1910.1450

This introduction summarizes the requirements of the OSHA Laboratory Standard, Code of Federal Regulations (CFR), Chapter 29, Section 1910.1450 entitled: "Occupational Exposure to Hazardous Chemicals in Laboratories." If you have any questions as to what is required for the development of the CHP, or wish to obtain a copy of the Laboratory Standard or information on any aspect of the Standard, contact Safety Services (368.2907).

GENERAL CONSIDERATIONS

CWRU SAFETY POLICY

This LSM has been written to acquaint all laboratory personnel with an important phase of their responsibility – safety, or accident prevention. Accident prevention must be included in the performance of every task. It cannot be considered a separate entity but is an integral part of everyone's work. Safety is made possible by careful planning of all work based on an understanding of the hazards involved and a knowledge of the work area and safe working procedures. Accident prevention pays in the injuries it prevents, the research time it saves, and the healthy attitude it creates.

The objective of this LSM is two-fold:

1. To provide general guidelines and recommendations for safe laboratory practices, and

2. To comply with OSHA's Laboratory Standard, 29 CFR 1910.1450.

This manual is not intended to be, nor can it be, complete and all-inclusive.

RESPONSIBILITY

The implementation of this policy is the responsibility of the managerial and supervisory staff of the University. Vice Presidents, Deans, Chairpersons, Directors, Heads of Units, Laboratory Supervisors, PIs, and all other supervisory personnel will be accountable for the health and safety of employees engaged in activities under their supervision. This responsibility cannot be delega

Safety Services will assist supervisory personnel in establishing and maintaining a safe working environment. EHS interprets the standards and regulations to ensure the safety, education, information monitoring, and recommendations for improvements. EHS will initiate the establishment of standards and regulations for safety, education, information monitoring, and recommendations for improvements. Safety Services will also maintain and provide general safety training, while PIs provide site-specific training.

c. Any incident in University Hospitals that involves CWRU personnel must be reported to Safety Services (368.2907) in addition to University Hospitals Protective Services (844.4357).

4. Post signs: “DANGER –

d. Broom or brush
e. Plastic bags
f. Hazardous waste labels
g. Rubber gloves (check chemical compatibility before use)
h. Rubber boots or foot protectors
i. Chemical splash goggles

LABORATORY DECOMMISSIONING PROCEDURES

Safety Services has developed certain decommissioning procedures for PIs whose research at CWRU will terminate. PIs who are leaving CWRU are responsible for proper disposal (or transfer to another PI with appropriate paperwork) of all commercial chemicals and research products. Contact Safety

SAFETY RULES FOR LABORATORIES

STANDARD OPERATING PROCEDURES

Introduction to Safe Laboratory Practices

A number of rules for safe laboratory practices are outlined below. This listing is intended to provide a practical base line for laboratories required to handle hazardous chemicals. Because of the nature of specific chemical hazards, this list is not comprehensive, but it will help PIs provide an appropriate safety plan for their laboratories. EHS is available for consultation on all safety and health-related issues.

1. General safety

    a. Be alert to unsafe conditions and actions, calling attention to them so corrections can be made as soon as possible. Safety is a community responsibility.

    b. Post warning signs and labels when unusual hazards such as radiation, lasers, flammable materials, infectious agents, or other special hazards exist.

    Caution/Emergency Information Signs (available from Safety Services) are to be posted on all entrances to the laboratory, clearly visible to personnel entering the lab. The Emergency Contact Information must be completed (listing two laboratory contacts) on each posted sign.

    c. Unauthorized minors and general population are prohibited in all laboratories.

    d. Visitors in laboratories must be accompanied by faculty, staff, or a graduate student. Visitors must wear the appropriate PPE in labs presenting a chemical or physical hazard.

e. No undergraduate laboratory class work shall be carried out in the absence of an instructor. Unauthorized experiments, as well as misconduct, are prohibited. Unapproved variations in experiments, including changing the quantities of reagents, may be dangerous and must be strictly guarded against in undergraduate laboratories.

f. DO NOT PERFORM HAZARDOUS PROCEDURES WHEN WORKING ALONE. This rule may be relaxed whenever there are other laboratory personnel in the area.

g. Eating, drinking, chewing gun, taking medications, applying cosmetics, and the use of certain hand lotions, as well as smoking, are prohibited in ALL laboratory areas.

h. According to OSHA Standard 29 CFR 1910.1030 (Occupational Exposure to Bloodborne Pathogens), hand lotion is not considered a cosmetic and is permitted. However, after this rule went into effect, it was brought to OSHA's attention that petroleum-based hand lotions affect the integrity of latex gloves. The following is a list of five recommended hand lotions that are non-petroleum based should:

- Johnson and Johnson Baby Lotion
- Cetaphil
- Jason Natural Cosmetics

Nexcare

- Keri Lotion

If you are concerned that the hand lotion you are using contains petroleum, contact Safety Services (368.2907).

2. Personal Protective Equipment (PPE)

a. The minimum PPE requirement for a laboratory is goggles/face shield, a buttoned laboratory coat, and appropriate chemically resistant gloves. **Laboratory coats, gloves, and other PPE shall not be worn outside the laboratory area.**

b. Clothing shall be appropriate to the laboratory – long pants and regular shoes, for example. Sandals or open-toed shoes, shorts, ties, or other dangling clothing can pose a safety threat in the laboratory.

c. Contact lenses are a risk when working with hazardous chemicals. Particulate matter, vapors, and liquids can lodge behind the contact lens, causing considerable eye damage before they can be washed with water from an eyewash station. In addition, solvent vapors can weld contact lenses to the eyes, requiring surgery to remove them.
d. Select appropriate gloves when working with toxic or corrosive materials. Call the glove manufacturer or consult Appendix C of this LSM for a discussion of glove compatibilities. Glove compatibilities can also be found under "Laboratory Safety" – "Glove Page" on the EHS website (http://case.edu/ehs) under "Chemical Safety."

e. Proper PPE must be worn at all times in the laboratory. Avoid

4. Safety with chemicals

    a. All heating of potentially hazardous chemicals must be performed in a chemical hood. Prior to heating a liquid, place boiling stones in vessels (other than test tubes). Use an alcohol thermometer (mercury thermometers are prohibited in laboratories) in a boiling liquid if there is the possibility of a dangerous exothermic decomposition, as in some distillations. Explosions are one of the most serious physical hazards in the laboratory.

    b. NEVER place your nose directly over a container to smell the contents.

    c. NEVER look down the opening of a vessel unless it is empty.

    d. Caution should be used when opening bottles which the lid or stopper is stuck. Wrap the bottle with a towel and place it in a container before applying additional force. The same precaution should be taken when opening ampoules.

    e. All containers with hazardous chemicals must be clearly labeled with the contents of the container. Use the complete chemical name, not the chemical formula or abbreviation (see Chapter Four).

    f. NEVER use any substance from an unlabeled or inadequately labeled container. Any unlabeled containers should be disposed of according to the University guidelines on waste disposal outlined in Chapter Four of this LSM.

    g. Flasks containing large volumes of toxic solutions, volatile solvents, boiling liquids and so forth, should be kept in pans large enough to contain the contents if the flask breaks. These should also be transported in appropriate transport containers.

    h. All chemicals or biological materials with an objectionable odor should be kept in the chemical hood or in an appropriately vented safety cabinet.

5. Waste disposal

    a. Hazards to the environment must be avoided by following the University guidelines on waste disposal outlined in Chapter Four of this LSM.

    b. Chemicals shall not be poured down the sanitary drains except for specific instances described in Chapter Four of this LSM.

Laboratory Practices for Specific Procedures

1. Flammable substances

    a. A chemical fume hood should be used for reactions in which flammable vapors are released (e.g. during the distillation of ether). If noxious or flammable gases are likely to be evolved in any process, the equipment must be confined to a chemical fume hood behind an explosion shield (see Chapter Two for a discussion of chemical fume hoods.)

    b. Ethers and other peroxide-forming chemicals should be dated when they are received and when they need to be disposed of. Ether should not be stored past the expiration date. Purchased ethers generally contain inhibitors to prevent the build-up of peroxides. Any distilled or processed ether no longer contains these inhibitors and should be used immediately or disposed of using the University guidelines on waste disposal for ethers described in Chapter Four of this LSM.

    c. Do not pour ether, petroleum, or other flammable water-immiscible liquids into the sanitary sink to be washed down with water. Fires and explosions have been caused in laboratories by vapors returning through the drainage system (e.g. during aspiration or rotary evaporation). See the University guidelines on waste disposal outlined in Chapter Four of this LSM.

    d. Dispose of glass in special waste receptacles designed and labeled for glass.

2. Reactive substances

    a. When conducting a reaction where there is a possibility of an explosion, use a face shield that is sufficiently large and strong enough to protect the face and neck, or use a standing shield. Goggles must be worn even when using a shield.

    b. When sodium, potassium, or lithium is used, the cuttings or residual pieces must be immediately disposed of by properly using the University guidelines on waste disposal described in Chapter Four of this LSM. Store these metals in oil, toluene, xylene, or other saturated hydrocarbon with a high boiling point.

    c. NEVER leave chemical reactions unattended that have not achieved kinetic equilibrium.

3. Corrosive substances

    a. Always pour acid into water. NEVER add water to acid as it can cause an exothermic reaction. For the same reason, pour concentrated solutions into water or less concentrated solutions while stirring.

    b. Always rinse the outside of acid bottles before opening them. Do not place a cap from an acid bottle on a surface where someone may rest a hand or arm. Keep acid bottles tightly closed. Rinse and dry them before storing them (dyightly ce tide of [(m)-3(ay)-1(r)- .o

5. Apparatus

    a. Use pipetting devices. Do not mouth pipette chemicals.

    b.

k. Sink traps and floor drains should be kept filled with water at all times to prevent escape of sewer gases into the laboratory. Such gases may be toxic or flammable and may be ignited, causing flash fires.

l. Do not use or place burners, hot plates, or non-explosion proof motors near experiments which may generate flammable gases.

m. Use beaker covers to prevent splattering when heating liquids on a hot plate. Keep a pair of tongs conveniently at hand. A specific tong for the dish crucible, beaker, casserole, or flask should be used.

n. In general, if the apparatus is likely to shatter either because of pressure or vacuum, surround it with mesh or cloth to limit the possibility of shards of shattered glass from becoming dangerous projectiles.

o. Glassware or any potential SHARPS (including chemical bottles and test tubes) should be set back from the front edge of the work bench to lessen the risk of injury if there is an accidental breakage of glass.

p. Adequate traps must be used in vacuum systems. When using a vacuum source, it is important to place a trap between the experimental apparatus and the vacuum source. The vacuum trap:

    i. Protects the pump and the piping from the potentially damaging effects of the material which could be infectious (if being used inside of bio-safety cabinet).

q. Protects maintenance workers who must work on the vacuum lines or system.

    Prevents vapors and related odors from being emitted back into the laboratory or system exhaust.

    Do not release the vacuum in any apparatus when the temperature is greater than 167ºF. The hot vapors may explode. To prevent contamination, all lines leading from experimental apparatus to the vacuum source should be equipped with filtration or other trapping as appropriate.

    i. For **particulates**, use filtration capable of efficiently trapping the particles in the size range being generated.

ii. For most **aqueous or non-volatile liquids**, a filter flask at room temperature is adequate to prevent liquids from getting to the vacuum lines and vacuum source.

iii. For **solvents** and other volatile liquids, use a cold trap of sufficient size and cold enough to condense vapors generated, followed by a filter flask capable of collecting fluid that could be aspirated out of the cold trap.

iv. For **highly reactive, corrosive or toxic gases**, use a sorbent canister or scrubbing device capable of trapping the gas.

v. Periodically disinfectant the chemical trap flasks. MAKE sure that disinfectant is compatible with chemicals collected in flask.

vi. Inline HEPA filters should be used as vacuum line filters; they should be inspected and replaced if clogged.

vii. Vacuum traps/flasks should be placed into secondary containers to prevent leakage in case of a broken flask.

r. Oven temperature regulators should be checked periodically to ensure the oven is functioning properly.

s. Bunsen burners should never be left burning when not in use. They should be turned off at the petcocks – do not depend upon the valve at the base of the burner.

t. Do not use natural gas in laminar flow or non-vented hoods.

u. Use laboratory approved heat guns in lieu of hairdryers. Switches and heating elements may cause a spark hazard.

PERSONAL PROTECTION: ADMINISTRATIVE CONTROLS, ENGINEERING CONTROLS, AND PPE

Introduction

Administrative controls, engineering controls, and PPE are designed to address and prevent hazards associated with the introduction of chemicals into the body. The major routes of entry into the body are inhalation, skin absorption, ingestion, injection, and subcutaneous entry. Engineering controls that ventilate gases, vapors, and small particulates are designed to eliminate the hazards associated with inhalation – the major route of entry. PPE is designed to eliminate exposure through all the above routes of entry and is to be used in conjunction with administrative and engineering controls.

Administrative Controls

Administrative controls are methodological procedures are those incorporated into activities in order to eliminate or minimize the potential for exposure to hazards. These include isolation of the operator or the process; hazards education; job rotation to limit time exposure to hazardous substances; substitution of less hazardous equipment or process (e.g. safety cans for glass bottles); and substitution of a less hazardous substance.

Engineering Controls

Engineering controls include tools or devices that reduce the hazard at the source. These include: Local and general ventilation (e.g. use of chemical fume hoods); use of biological safety cabinets or glove boxes; placing walls or

2. Chemical hoods

    a. In general, chemical hoods offer two significant types of protection from atmospheric exposure to hazardous materials:

        i. Local ventilation to prevent toxic, offensive, or flammable vapors from entering the room.

        ii. A physical barrier between the researcher and the chemical reaction when that reaction is performed in a chemical fume hood, especially with the chemical fume hood sash closed. This barrier can protect the researcher from hazards such as chemical splashes or sprays, fires, and minor explosions.

    Chemical fume hoods should be considered primary safety devices that can contain and exhaust toxic, offensive, or flammable materials when the design of an experiment fails and particles or gases/vapors escape from the apparatus being used. Fume hoods should never be used as a means of disposing chemicals.

    Chemical fume hoods are tested at least annually by Safety Services, using two methods of testing:

        iii. Velocity testing is performed annually on each chemical fume hood with a smoke test to assure that the chemical fume hood has not deviated from the conditions under which the hood passed its ASHRAE 110 Tracer Gas test.

        iv. ASHRAE 110 Tracer Gas testing is performed on each chemical fume hood once in a five-year cycle. The fume hood is velocity tested during the other two years. The ASHRAE 110 Tracer Gas test utilizes SF_6 (sulfur hexafluoride) as a tracer gas that is released into the fume hood. A gas detector is used to measure leakage from the hood under varying conditions. If the fume hood does not spill more than an average of 100 ppb of SF_6 during the test, the fume hood passes this test.

    If you need assistance or more information about a chemical fume hood in one of your laboratories, or if your chemical fume hood is not posted with a label or sticker showing that it has been tested within the past year, contact Safety Services (368.2907).

NOTE: Use perchloric acid only in a specifically designated chemical fume hood. DO NOT use other chemicals in that chemical hood. Clearly mark that the chemical fume hood is for use only with perchloric acid.

b. Safe chemical fume hood work practices

   i. Keep work surfaces within the fume hood clear.

   ii. Make sure the exhaust blower is operating and air is entering the fume hood prior to starting an experiment.

   iii. If there is a problem with airflow, call Plant Services (368.2580). They will notify Safety Services, if necessary.

   iv. Do not disable flow measurement devices or alarms.

   v. Work with the sash at the proper operating level as indicated by Safety Services' sticker test arrows.

   vi. Do not place your face inside of a chemical fume hood. Keep hands out as much as possible.

   vii. Keep sources of emission at least six inches inside the fume hood.

   viii. Do not store chemicals in the fume hood. Immediately clean-up minor spills. Provide catch basins (secondary containers) for containers that could break or spill, to minimize the spread of spilled hazardous materials.

   ix. Avoid blocking the baffle exhaust slots in any manner. Keep large equipment two inches off the base of the chemical fume hood and at least two inches from the sides of the hood.

   x. Be aware of other room ventilation factors that may interfere with the chemical fume hood operation, such as open doors and windows, blocked exhaust ports, or heating and air conditioning vents.

   xi. Avoid cross drafts and disruptive air currents in front of the chemical fume hood.

xii. Use the sash as a safety shield when boiling materials or conducting an experiment with reactive materials.

xiii. Close the chemical fume hood sash when the hood is not in use.

3. Laminar airflow equipment

Two types of laminar airflow equipment – the Biological Safety Cabinet (BSC) and the laminar flow clean bench – are discussed in this section. NOTE: Laminar flow hoods are not safety devices.

a. BSC – If biological safety is an issue with your work, use a BSC with or without glove attachments as warranted by the experiment. BSC's include 100% exhaust laminar flow hoods and glove boxes with chemical traps or exhaust access to a chemical fume hood.

Laminar flow equipment (including BSCs) will be leak tested, adjusted, or repaired by a certified contractor. Submit a request for repair or recertification, available on the EHS website (http://case.edu/ehs) under "Biological Safety."

b. Laminar flow clean bench – Protects the product from airborne contamination but does not protect the operator. Because of the risk to personnel, working with hazardous materials on a laminar flow clean bench is not advisable. Use of clean benches should be limited to the preparation of sterile media, the assembly of sterile components into complete units (e.g. membrane filters), the examination of sterilized equipment and materials for possible contamination, and similar operations. **Work with pathogens is not permitted.**

A large number of companies manufacture both vertical and horizontal laminar flow clean benches. Most of the commercially available equipment is adequate when:

i. The High Efficiency Particulate Air (HEPA) filter has been tested and certified. To meet standards, this filter should be at least 99.97% efficient in removing particles 0.3 microns or larger by the Dioctylphthalate (DOP) test.

ii. The HEPA filter housing has been properly sealed around the edges to prevent unfiltered air from bypassing the filter.

iii. The airflow is adjusted to 80-100 linear feet per minute.

The pre-filter is periodically cleaned or replaced when the magnahelic gauge indicates it is full because of a pressure drop.

4. Biological Safety Cabinet

   The BSC protects both product and operator and may be used for organisms which exceed Biosafety Level 2. (See CDC/NIH publication "Biosafety in Microbiological and Biomedical Laboratories" for a list of organisms and applicable biosafety levels. Check the CDC/NIH website regularly for updated information: http://www.cdc.gov/ods/ohs.) Safety and desirability of using this equipment to contain infectious material should be determined on an individual basis, depending upon the agent, the proposed activity, and the need to prevent cross-contamination. This hood, however, cannot replace the standard gastight Class III BSC for extremely hazardous work.

   Do not use open flames in a BSC.

Personal Protective Equipment

Along with carefully planned work practices, administrative and engineering controls, PPE is the key element in minimizing the potential for worker exposure to hazardous chemicals. Proper use of PPE requires that the supervisor assess the hazard presented and attempt to apply administrative and/or engineering controls first. PPE is used when administrative and/or engineering controls will not be effective.

The performance of PPE as a barrier to chemicals is determined by the materials and quality of its construction. Three important factors to keep in mind when considering PPE are:

i. In general, there is no such thing as "impermeable" plastic or rubber clothing;

ii. No one clothing material will be a barrier to all chemicals; and

iii. For certain chemicals or combination of chemicals, there is no commercially available glove or clothing that will provide more than an hour's protection following contact. In this case, it is recommended that PPE be changed frequently or as soon as it comes into contact with chemicals or hazardous mixtures.

Of principal importance in the selection of PPE for protection from chemicals is: the rate at which chemicals permeate clothing materials, and the time elapsed

between the contact with the chemical, and the appearance of the chemical on the inside of the PPE (called breakthrough time).

1. Respiratory Protection

   The basic purpose of any respirator is to protect the respiratory system from inhalation of hazardous atmospheres. Respirators provide protection either by removing contaminants from the air before it is inhaled or by supplying an independent source of respirable air.

   Safety Services has implemented a comprehensive Respiratory Protection Program. This training involves a physical examination at University Health Services, getting fit-tested with a respirator through Safety Services, and receiving proper training. Refer to the CWRU Respiratory Protection Program, which can be found on the EHS website (http://case.edu/ehs) under "Laboratory Safety – Forms and Manuals". Annual retrain and fit-test are required for all respirator users. Respirator use, mandatory or voluntary, requires prior approval from Safety Services.

2. Dermal protection

   a. Gloves – Type of PPE that serves as hand protection and used to prevent cuts, abrasions, burns, and skin contact with chemicals that are capable of causing local or systemic effects following dermal exposure. Proper gloves must be used in the laboratory and should be selected on the basis of chemical compatibility (see Appendix C). In general, latex gloves do not provide adequate protection and are not recommended for any chemical operation. Reusable gloves that are readily available on campus include: Neoprene and nitrile-butadiene rubber. For the best gloves to use with your laboratory process, contact Safety Services (368.2907), or refer to the glove compatibility table listed in Appendix C of this LSM, or refer to the EHS website (http://case.edu/ehs) under "Laboratory Safety – Glove Page."

   b. Laboratory coats – Should always be worn during active work in the laboratory and should be buttoned completely. Laboratory coats are loose-fitting by design so, in case of chemical contact, there is ample time to react before a chemical gets to the undergarments and ultimately to the skin. Laboratory coats shall not be taken home for any reason. They are not to be laundered in a public laundromat; instead, arrangements should be made in the laboratory group for laundry service.
      Refer to the EHS website (http://case.edu/ehs) under "Laboratory

incompatible chemicals or consult an MSDS.

6. Label all containers (new bottles as well as temporary containers) properly with the following information: Your name, PI name, date, contents, purity location, hazards (if known).

7.

flammable storage cabinet.

2. Different types of storage cabinets are sold by laboratory supply firms. Acids and bases shall be stored in separate storage cabinets manufactured specifically for corrosives, or one cabinet with two isolated sections. In both cases, there shall be no risk of acids and bases coming into contact with each other in case of a spill or accident.

3. Maintaining neutralizing agents for acid and base spills is recommended.

4. Acids and bases shall not be stored with active metals such as sodium, potassium, or magnesium. Contact Safety Services for more information.

Hazardous Waste Storage

The proper storage of hazardous chemical waste is no different than the proper storage of hazardous chemicals. Hazardous waste is still hazardous chemicals.

1. Segregate the hazardous chemical waste by chemical properties to avoid adverse reactions.

2. Store flammable liquid waste in a flammable liquids storage cabinet or in containers clearly marked “Hazardous Waste”.

3. Do not store chemical waste acids with waste bases.

4. Do not store chemical waste oxidizers with flammable liquids.

5. Segregate all hazardous waste toxic materials from acids, oxidizers, and flammable liquids.

6. Hazardous waste can be stored properly with chemicals still in use as long as care is taken to avoid incompatibilities.

7. All hazardous waste chemicals must be labeled with the words “Hazardous Waste,” AND the chemical contents of the waste container.

Chemical Compatibility Chart

Group 1-A	Group 1-B
Alkaline Liquids	Acid Liquids
Potential consequences: Heat generation, violent reaction	

Group 2-A	Group 2-B
Aluminum Beryllium Calcium Magnesium Sodium Other reactive metals and metal hydrides	Wastes in Group 1-A or 1-B

Potential consequences: Fire or explosion generation of flammable hydrogen gas

Group 3-A	Group 3-B
Alcohols Water	Concentrated waste in Groups 1-A or 1-B Calcium Lithium Metal hydrides Potassium SO2Cl2, SOCl2, PCl3, CH3SiCl3 Other water-reactive wastes

Potential consequences: Fire, explosion, or heat generation; generation of flammable or toxic gases.

Group 4-A	Group 4-B
Alcohols Aldehydes Halogenated hydrocarbons Nitrated hydrocarbons Unsaturated hydrocarbons Other m0 /Ti re W n BT /TT Tm [(N)2	Concentrated Group 1-A or 1-B wastes Group 2-A wastes

Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas

Group 6-A	Group 6-B
Chlorates	Acetic acid and other organic acids
Chlorine	Concentrated mineral acids
Chlorites	Group 2-A wastes
Chromic acid	Group 4-A wastes
Hypochlorites	Other flammable and combustible wastes
Nitrates	
Nitric acid, fuming	
Perchlorates	
Permanganates	
Peroxides	

Potential consequences: Fire, explosion, or violent reaction.

CWRU HAZARD WARNING SIGNS

In an effort to bring the system of signs used at CWRU into agreement – to warn of danger and to direct pedestrian traffic away from laboratory work areas – uniform hazard warning signs have been designed. This LSM describes these

material that would damage the doors, walls, or building when the signs are removed.

NFPA Signage

OSHA has adopted the National Fire Protection Association's (NFPA) standard 704 signage to indicate the hazards present in a given location. The NFPA diamond contains four sections. Each section contains a number from zero (for minimal hazard) to four (for the highest possible hazard). These signs shall be posted outside each laboratory and shall be filled in with the information on the highest possible hazard present in each laboratory. The color of the diamond indicates the type of hazard, while the number represents the degree of hazard.

Availability of Signs

The PI in charge of the laboratory is responsible for obtaining the appropriate signs and frames. These are available through most laboratory supply

Most exposure standards, Threshold Limit Values (TLVs), and Permissible Exposure Limits (PELs), are based on the inhalation route of exposure when airborne gases, fumes or particulates of the chemical enter the body via respiratory system. These limits are normally expressed in terms of either parts per million (ppm) or milligrams per cubic meter (mg/m^3) in air.
If a significant route of exposure for a hazardous substance is through skin absorption, its MSDS will have a "skin" notation. Examples include pesticides, carbon disulfide, carbon tetrachloride, dioxane, mercury, thallium compounds, xylene, hydrogen cyanide, and benzene.

Exposure Definitions

1. **Acute** poisoning is characterized by rapid absorption of the substance and the exposure is sudden and severe. Normally, a single large exposure is involved. Examples include carbon monoxide or cyanide poisoning.

2. **Chronic** poisoning is characterized by prolonged or repeated exposures of a duration measured in days, months, or years. Symptoms may not be immediately apparent. Examples include lead or mercury poisoning, and pesticide exposure.

3. **Local** refers to the site of action of an agent and means the action takes place at the point or area of contact. The site may be skin, mucous membranes, the respiratory tract, gastrointestinal system, eyes, etc. Absorption does not necessarily occur. Examples include strong acids or alkalis.

4. **Systemic** refers to a site of action other than the point of contact where presupposed absorption has taken place. Examples include an inhaled material that may act on the liver; arsenic affects on the blood, nervous system, liver, kidneys, and skin; benzene affects in bone marrow.

5. **Cumulative** poisons are characterized by materials that tend to build up in the body as a result of chronic exposure. The effects are not seen until a critical body burden is reached. Examples include heavy metals.

6. **Synergistic** or **potentiating** effects occur when two or more hazardous materials are present in combination. The resulting effect can be greater than the effect predicted based on the individual substances. Examples include transport or carrier substances, such as dimethylsulfoxide (DMSO), which is readily absorbed through the skin and can carry with it a more dangerous substance, which by itself is not easily absorbed.

Other Factors Affecting Toxicity

1. Rate of entry and route of exposure.

2. Concentration of chemical present in the air or amount of chemical absorbed into the body.

3. Age of affected individual, possibly affecting the capacity to repair tissue damage.

4. Previous exposure history, possibly leading to tolerance or increased sensitivity.

5. State of health, physical condition, and lifestyle. Pre-existing disease can result in increased sensitivity.

6. Environmental factors such as temperature and pressure.

7. Host factors including genetic predisposition and the sex of the exposed individual.

MATERIAL SAFETY DATA SH(i)1(c(i)1E1(l))1(t)-o</Attached [/BT9

When considering the toxicity of gases and vapors, the solubility of the substance is a key factor. Highly water-soluble materials, such as ammonia, irritate the upper respiratory tract. However, low water-soluble materials, such as nitrogen dioxide, penetrate deep into the lung. Fat-soluble materials, such as pesticides, tend to have longer residence times in the body.

3. A **liquid** is the state of matter between a solid and a gas. Liquids present skin and ingestion hazards. A liquid can evaporate to the gaseous state and present a respiratory hazard.

4. An **aerosol** (including smog, smoke, fumes, etc.) is composed of microscopic solid or liquid particles dispersed in a gaseous medium. The toxic potential of an aerosol is only partially described by its concentration in milligrams per cubic meter (mg/m^3). For a proper assessment of the toxic hazard, the size of the aerosol's particles is important. Particles above 5 µm tend to deposit in the upper respiratory tract. Particles below 5 µm enter the lungs. Very small particles (<0.2 µm) are generally not deposited but are instead absorbed like gases or vapors.

Physiological Classifications

1. Respiratory

    a. **Mucous membranes** (nose, mouth, throat, lungs) may become inflamed by contact with certain chemical irritants. Inflammation of

3. Systemic

    a. **Hepatotoxic agents** cause damage to the liver. Examples include carbon tetrachloride, nitrosamines, and tetrachloroethane. Signs and symptoms include jaundice, and liver enlargement.

    b. **Nephrotoxic agents** damage the kidneys. Examples include halogenated hydrocarbons, and uranium compounds. Signs and symptoms include edema, and proteinurea.

    c. **Neurotoxic agents** damage the nervous system. The nervous system is especially sensitive to organo-metallic compounds and certain sulfide compounds. Examples include carbon disulfide, manganese, methyl mercury, organo-phosphate insecticides, tetraethyl lead, thallium, and triakyl tin compounds. Signs and symptoms include narcosis, behavioral changes, and decrease in motor function.

    d. **Hematotoxic agents** act on the blood, bone marrow, or hematopoietic system. Examples include aniline, benzene, nitrites, nitrobenzene, and toluidine. Benzene damages bone marrow which can lead to leukemia. Signs and symptoms include cyanosis (a bluish coloration to the skin) and loss of consciousness.

    e. **Carcinogenic agents** can initiate or speed the development of malignant or potentially malignant tumors or other malignant neoplastic proliferation of cells. Known human carcinogens are listed in Appendix B.

    f. **Reproductive toxins** cause damage to either the reproductive system directly or to the fetal tissue. 1,2-dibromo-3-chloropropane (DBCP) causes infertility (azoospermia) in males, while lead and ethylene oxide can cause infertility in males and females. **Teratogens** (embryotoxic or fetotoxic agents) interfere with normal embryonic development without damage to the mother or lethal effect on the fetus. Effects are not hereditary. Examples include lead, and DBCP (see Appendix B for a list of reproductive toxins).

h. **Cardiotoxic agents**

3. Disposable gloves should be discarded after each use and immediately after overt contact with extremely hazardous chemicals. Gloves should never be worn outside of the laboratory area.

4. All personnel must wash their hands immediately after removing gloves and after the completion of any procedure using chemical hazards.

Operational Procedures

1. Work areas within a laboratory, where carcinogens or reproductive hazards are used, should be clearly marked with a warning sign which reads: "CAUTION – POTENTIAL CANCER HAZARD, AUTHORIZED PERSONNEL ONLY" or "CAUTION – POTENTIAL REPRODUCTIVE TOXIN, AUTHORIZED PERSONNEL ONLY." Those areas used for storage of these chemicals should also be identified in a similar manner. Chemical-specific signs and labels are available from Safety Services.

2. Work areas where select hazards are being used should only be entered by authorized personnel. When extremely hazardous chemicals aremkhardouseli1 har-1.1

The use of PPE or chemical fume hoods may substantially reduce exposures and they are of particular significance for a pregnant employee. Examples of reproductive toxins include benzene, mercury, ethylene dibromide, carbon monoxide, anesthetic gases (halothane), ionizing radiation, ethylene oxide, and glycidyl ethers. A more complete list of known reproductive hazards is presented in Appendix B. In addition, the MSDS may be consulted for information on additional chemicals with reproductive toxicity which may be in use in the laboratory. Safety Services is available for consultation on both hazards and means of reducing exposures.

Working with Substances with High Acute Toxicity

The Laboratory Standard requires that "**substances with high acute toxicity** such as hydrogen cyanide, hydrogen sulfide and nitrogen dioxide are included under the category of substances for which employers must consider the need for special precautions. Such substances may be fatal or cause damage to target organs as a result of a single exposure or exposures of short durations."

Experimentation with Animals

The use of extremely hazardous chemicals in experimental animals must be arranged with the personnel in the ARC. Call 368.34/3j4ed witor consult cus(pec)-1(i)1.835 0(n ex)

Skin protection is afforded by face shields, caps, gloves, gowns, etc. Overexposure to UV radiation should be reported to University Health Services.

For further information regarding UV radiation exposure, consult the EHS Physical Safety Manual available on the EHS website (http://case.edu/ehs

WASTE DISPOSAL AND WASTE REDUCTION

This chapter discusses the University procedures for all types of hazardous waste classifications, containment, labeling, and handling. These procedures are necessary for compliance with regulations of the United States and Ohio Environmental Protection Agencies (EPA & OhioEPA), the Nuclear Regulatory Commission (NRC), the Department of Transportation (DOT), the Occupational Health and Safety Administration (OSHA), and the Ohio Department of Health (ODH).

PIs and area supervisors must ensure that the appropriate personnel follow the procedures outlined in this LSM. Call Safety Services (368.2907) with specific hazardous waste disposal questions or problems. In the University Hospitals' area, contact UH Safety (844.1458) for hazardous waste disposal procedures. For disposal of SHARPS and biohazardous waste in CWRU buildings, contact Customer Services (368.2580) to schedule a pick-up. In University Hospitals' buildings, contact the Environmental Services Department (844.3071).

The following general classes of chemicals are incompatible with one another:

General Classes of Incompatible Chemicals*	
Acids, oxidizing agents	**Bases, metals, reducing agents**
Chlorates	Ammonia, Anhydrous and aqueous
Chromates	Carbon
Chromium trioxide	Metals
Dichromates	Metal hydrides
Halogens	Nitrites
Halogenating agents	Organic compounds
Hydrogen peroxide	Phosphorus
Nitrates	Silicon
Nitric acid	Sulfur
Perchlorates	
Peroxides	
Permanganates	
Persulfates	

i. Broken mercury thermometers

    i. Attach a hazardous waste tag to the container with broken mercury thermometer and label the material as “broken thermometer and elemental mercury.”

    ii.

Disposal of Chemicals in Sanitary Sewers (Drains)

Hazardous wastes are regulated by the EPA under the Resource Conservation and Recovery Act (RCRA). In general, these regulations do not permit any drain disposal, except for those items listed below. For questions, contact Safety Services (368.2907).

1. Inorganic acids and bases that have a pH between 5 and 10.

   These pH limits are imposed by regional sewer regulations. Sewer disposal is permitted provided no other regulated chemical is present. Neutralization is permitted to change the pH to within acceptable limits if it is written into the experiment's protocol.

2. Aqueous buffer solutions containing no regulated materials or biohazardous threat (e.g. common salt solutions or tissue culture media).

   Such solutions may contain millimolar concentrations of common biochemicals, buffers, serum by-products, or cell metabolites. When in solution, common salts (chlorides, bromides, bicarbonates, citrates, phosphates, sulfates, acetates) of sodium, potassium, magnesium, ammonium, and calcium may be disposed in the sanitary sewer.

3. Aqueous High Performance Liquid Chromatography (HPLC) solutions or other solutions containing less than 24% ethanol, propanol, or isopropanol (no other alcohols).

   The 24% limit is based on flammability of the alcohol. HPLC solutions containing any amount of acetonitrile or other organic solvents must be disposed through Safety Services. In University Hospitals, contact UH Safety (844.1458) to arrange for disposal of these chemicals.

4. Bacteriological and tissue culture media.

   All media containing live organisms must be sterilized by autoclaving or by another acceptable procedure and must not contain anything other than common biochemicals. Serum byproducts or cell metabolites containing azides or thioglycolate must be disposed by Safety Services or, in University Hospitals, by UH Safety.

5. Mixed waste handling must be taken care of properly, and all waste handling protocols must be included in the laboratories Chemical Hygiene and Exposure Control Plans. **SAFETY SERVICES and/or THE RADIATION SAFETY OFFICE MUST BE CONTACTED BEFORE ANY MIXED WASTE IS GENERATED FOR DISPOSAL.** Mixed wastes include:

a. Radioactive-Chemical mixed waste must be classified by chemical and level of radioactivity before drain disposal. Refer to the Radiation Safety Laboratory User Manual for disposal p

Before any destruction, please contact Safety Services (368.2907) to obtain permission and to verify the procedure. Destruction of select agents and toxins requires a 5-day notice to either APHIS or CDC. **Ignoring the notification procedure can result in fines and/or imprisonment.**

DISPOSAL OF OTHER LABORATORY WASTE

Classification of Waste and Disposal Procedures

Prior to disposal, non-chemical waste must be classified as one of the following: SHARPS, non-SHARPS, or uncontaminated laboratory waste.

Wastes which contain both chemical waste and another type of waste (e.g. animal parts stored in formalin) must be separated and disposed according to each pertinent waste policy. That is, the animal waste is disposed as biohazardous waste, and the formalin is disposed as chemical waste.

In addition, local landfills no longer permit the University to dispose of any biohazardous waste (whether or not autoclaved) or SHARPS in the regular trash. Therefore, it is essential to classify waste properly. Safety Services is available for consultation on a case-by-case basis. A summary of the following "bag" policies is described below. For University Hospitals, contact Environmental Services (844.3071) for information on disposal of biohazardous waste.

SHARPS

Definition: Examples include discarded hypodermic needles, syringes, and scalpel blades; cannulas, coverslips, microscope slides, all pipettes (glass or plastic) and pipette tips, test tubes, and glass Petri dishes; glassware, and any other item capable of causing puncture wounds or cuts.

Procedure: All SHARPS, contaminated or not, must be contained in puncture-resistant containers. Call Customer Service (368.2580) for disposal.

a. All needles, syringes, and scalpel blades; and any SHARP designed for use in biological, etiological, bacteriological, or tissue culture work must be placed in red rigid SHARPS containers. Call Purchasing (368.2560) for a list of vendors. **Hypodermic needles should not be recapped, clipped, broken, or disassembled.**

records for all instruments and equipment (including pH meters, analytical balances, incubators, refrigerators, autoclaves, and water baths). Steam sterilization for the appropriate amount of time and at the proper temperature is the simplest, most effective method. STEAM SHOULD BE CONDUCTED AS CLOSE TO THE POINT AND TIME OF WASTE GENERATION AS POSSIBLE.

All waste must be sterilized in red or orange biohazardous bags. All bags must be able to be autoclaved and conspicuously labeled with the international biohazard symbol. Biohazard bags can be ordered from scientific supply houses. After sterilization and cooling, these bags are to be denoted "sterilized" and tagged with the PI's name and date of sterilization.

NO SHARPS (which includes glass, plastic pipettes and tips) are permitted to be placed in these autoclaved bags or any other bag. Such SHARPS are a hazard when handling these bags and cause contaminants to leak from bags in transit. They must be disposed if in a red rigid SHARPS container as biohazardous SHARPS.

After all autoclaved biohazardous waste has been appropriately tagged, Custodial Services will remove the waste in the evening for incineration. Arrangements for pick-up must be made by contacting Customer Service (368.2580) by 4:30 p.m. All biohazardous bags must remain in the laboratory for evening pick-up. Biohazardous waste must be disposed of expeditiously.

Liquid biomedical waste that has been treated to render it non-infectious can be poured in the sanitary drain, which should then be flushed with water.

EXCEPTIONS

a. Any liquid biomedical waste which contains radioactive materials. Contact Radiation Safety (368.2906) to receive disposal instructions for this exception or refer to the Radiation Safety Laboratory User Manual.

b. Any liquid biomedical waste which contains hazardous chemicals as set forth in the University Chemical Disposal Policy. Contact Safety Services (368.2907) to receive disposal instructions for this exception.

3. Uncontaminated laboratory waste

Definition: All laboratory waste which has not been contaminated by radioactive, chemical, or infectious agents, such as: Petri plates, plastic

disposal for the unused portion of the chemical greatly exceeds the initial savings. The University's supplies store (Fisher Scientific stock room) sells chemicals in smaller quantities at bulk prices to facilitate waste minimization in laboratories.

2. Post-experiment techniques

    a. When cleaning with solvents, use spent solvent for the initial cleaning and use fresh solvent only for the final rinse.

    b. Destroy wastes as part of the last step of the experiment, if possible, provided the result is not a regulated material (call Safety Services to confirm). Such end-procedure neutralization techniques include oxidation-reduction, or precipitation and filtration of solids.

    c. Label all containers, new or temporary, with the proper information, even if the solutions they contain are innocuous. Disposing of an "unknown" waste, which is what materials in unlabeled containers often become, requires time-consuming and costly analysis. In addition, unknowns are dangerous in that they may explode or cause adverse reactions.

Recycling Proceduresonty,-3(t)-3(em(equi)1(-1(,)-3u1(s)-1(i)1008 Tw 1(y)-4i)1(-1(,u1(s)-1(i)1 1(r)

E-Waste

Computers and computer monitors and other electronic devices contain large amounts of lead in the solder of the circuit boards. Monitors in the form of Cathode Ray Tubes (CRT) also contain barium. Both are highly regulated materials. If you wish to dispose of any electronic waste please complete the online e-Waste disposal request form which can be submitted via email by clicking the "SUBMIT" button at the bottom of the form. The form can be found on DOES web site under “Laboratory Safety” link:
https://www.case.edu/ehs//LabSafety/equipment.html

SPECIFIC LABORATORY PROCEDURES

CHAPTER FIVE

CENTRIFUGE SAFETY

This LSM provides standards for the use of bench and floor centrifuges commonly used in clinical and biochemical laboratories, and procedures to be followed if a centrifuge accident occurs. Each employee using the centrifuge must become familiar with requirements for operation of the instrument. Assistance is available upon request from Safety Services (368.2907).

Each employee shall be instructed on proper operating procedures before being permitted to use the centrifuge. Instructions should include requirements for balancing loads, using the proper centrifuge head, and using accessory equipment. Conditions for loading and operating an ultra-centrifuge and preparative centrifuge vary considerably. Therefore, even experienced investigators should review procedures before operating an unfamiliar instrument.

Each employee who uses a centrifuge is responsible for the condition of the machine at the end of the procedure. This includes entering data in the log book, turning off the power, and cleaning spills, broken glass, etc. Detailed records of operation should be made for most high-speed centrifuges and rotors. The safe speed that rotors can be operated is determined by a rating formula which is based on numbers of starts and stops, rpm, and total “G” loads. Also, warranty coverage and service procedures for the machine are determined by hours of operation. These records should be kept in log books placed near each machine.

1. Safety precautions

    a. Laboratory area

        Rooms where live etiologic agents are centrifuged should be identified with a warning sign. Because of the hazards involved, continuous flow centrifugation of live etiologic agents may be done only in installations approved by Safety Services, including using batch type zonal rotors that require seal disconnection when in operation. This protocol must be included in the laboratory’s Exposure Control Plan.

b. Tubes

Reusable centrifuge tubes and centrifuge buckets should be carefully inspected prior to each ultra-centrifuge cycle. Only sound tubes and buckets should be used to process infectious material. Reusable tubes used in an ultra-centrifuge are subjected to great pressure, which sometimes causes them to break, especially after they have been through several cycles. Tubes likely to fail can often be identified by stress lines which appear in the area of junction of the sides and the bottom. Such tubes should be discarded.

Tubes to be used in angle-head centrifuges must never be filled to the point that liquid is in contact with the lip of the tube when it is placed in the rotor, even though the meniscus will be vertical during rotation. When the tube lip is wetted, high G forces drive the liquid past the cap seal and over the outside of the tube.

Nitrocellulose tubes should be used only when “fresh,” meaning, clear, without discoloration, and flexible. Small lots should be ordered several times a year instead of one large lot once a year. Storage at 4ºC extends shelf life. Used nitrocellulose tubes should be disinfected in a solution known to be effective against the agent being processed and discarded as solid waste.

c. Carrier rotors and cups

Rotor corrosion can create a hazardous condition, best prevented through cleanliness. Ultra-centrifuge heads in particular must be protected. After each use, the rotor should be rinsed in warm tap water and then with distilled water. If solid deposits persist, clean with a mild detergent solution and a stiff test tube brush. Do not scratch the surface of the tube wells in aluminum rotors. Rinse off the detergent with warm tap water and distilled water, and dry before use. Since caustic solutions are particularly damaging to rotors, clean them promptly after use.

When centrifuge tubes are used in dirty or rough cups, the tubes expand and seize against the walls of the cup, making it very difficult to remove the tubes. In some instances, tubes have had to be pulled with pliers and have been torn or broken in removal. To avoid this possibility, the inside of the cups may be sprayed with a silicon aerosol spray or similar product (see instructions that come with these ultra-centrifuges, as rotors require special care which may differ from instructions in this guide).

2. Post-accident procedures

    a. Major accident

        In case of a major centrifuge accident involving potential exposure to hazardous chemical or biological materials, immediately contact Safety Services (368.2907) for instructions.

    b. Spill response

        Clean-up and decontamination of laboratory equipment for reuse are the responsibilities of the user. Safety clearances for disposal of equipment contaminated with biohazardous or radioactive materials will be carried out by EHS If the spill involves pathogens or radioactive materials, EHS must be contacted immediately (Safety Services: 368.2907; Radiation Safety: 368.2906). In University Hospitals, contact UH Environmental Services (844.3071) for instructions on disposal of biohazards.

COMPRESSED GASES IN CYLINDERS

f. Use the proper regulator for the particular gas.

g. Always consider cylinders to be full and handle accordingly.

h. Cylinders should be considered empty when approximately 25 psi still remains, in order to prevent contaminated air from entering the tank.

i. See the table below for maximum size and quantity of cylinders permitted in any one laboratory unit.

	Flammable Gases and/or Oxygen Sprinklered Space	Flammable Gases and/or Oxygen Nonsprinklered Space	Liquified Flammable Gases Sprinklered Space	Liquified Flammable Gases Nonsprinklered Space	Gases with Health Hazard Rating of 3 or 4
Max. number of cylinders per 300 sq. ft. or less	6	3	3	2	3
Max. cylinder size (in.)	10 x 50	10 x 50	9 x 30	9 x 30	4 x 15
Approx. water volume (ft.)	2.0	2.0	0.6	0.6	0.1

j. Identify the contents of cylinders with decals, stencils, glued or wired-on tags, or other markings on the cylinders. Color codes alone or tags hung around the necks of the cylinders are not acceptable. Cylinders lacking proper identification must not be accepted from the vendors. A safe handling procedures sign should be posted above the cylinder storage area. The information about compressed gas cylinders safety can be found on EHS web site under “Chemical Safety”.

k. Employees must not attempt to repair cylinders or cylinder valves, or to apply force to stuck or frozen cylinder valves.

l. Empty cylinders must be marked “EMPTY” or “MT” with grease pencils. Generally, this marking should be on a large piece of adhesive or masking tape secured to the cylinder. Some cylinders

Purchase and use of the following gases are controlled and some require respirator training before use:

Ammonia	Iodine pentafluoride (liquid shipped in gas-type cylinder)
Arsine	Methyl bromide (bromomethane)
Boron trifluoride	Methyl chloride
Chlorine	Nitric oxide
Dimethylamine	Nitrogen dioxide (nitrogen tetroxide)
Ethylene oxide	Nitrogen trioxide
Fluorine	Nitrosyl chloride (nitrogen oxychloride)
Hydrogen bromide (hydrobromic acid)	Phosgene
Hydrogen chloride (hydrochloric acid)	Silicon tetrafluoride (tetrafluorosilane)
Hydrogen fluoride (hydrofluoric acid)	Sulfur dioxide
Hydrogen sulfide	

3. Safety Services will notify PIs in charge of laboratories as soon as a EHS specialist determines that requirements for safe use of the gas have been fulfilled. PIs planning to use these gases are reminded that some of them are extremely toxic and may require both isolated laboratory space and equipment that is not immediately available. Additional training may also be required for some gases such as ethylene oxide or hydrogen. For these reasons, certification for use should be requested well in advance of the proposed use.

Flammable Gases

Because of the fire and explosion hazards that can result when these products are used in confined spaces, special care must be taken:

1. When reactive cylinders are kept inside a building, do not manifold two or more cylinders together. However, several instruments may be operated from one cylinder.

2. If more than one cylinder of highly flammable gas is to be placed in a laboratory, written permission must be obtained from Safety Services. Consideration for granting permission will include size and location of the room, airflow, other equipment in use, and ease of access to cylinders.

3. Standby cylinders of flammable gases (full reserve cylinders) or empty cylinders must not be stored in laboratories. Cylinders must be stored in restricted, shaded spaces outside and delivered to the laboratory on demand.

4. Limit cylinder size to 210 cubic feet.

5. Close valves on flammable gas cylinders before all employees leave the laboratory at the end of their work day, unless the cylinders are being used in a controlled experimental environment.

6. Tank adapters may be used only upon written permission from Safety Services. Only the approved regulator and valve units specified for use with a specific gas may be used.

7. Piping must be compatible with the gas (e.g. no copper piping for acetylene; no plastic tubing in any high-pressure portion of a system).

8. Only the appropriate regulator and valve unit specified for use with a specific gas may be used.

Accepting Cylinders from Vendors

1. The contents of cylinders must be identified with decals, stencils, glued or wired-on tags, or other markings on the cylinders. Color codes alone or tags hung around the necks of the cylinders must not be used. Cylinders lacking proper identification must not be accepted from a vendor.

2. Cylinders must not be accepted from a vendor unless the valve safety covers are in place and properly tightened.

3. Cylinder valves must conform to standards of the National Compressed Gas Association (i.e. they must be in serviceable condition and free of corrosion).

Pressure Regulators and Needle Valves

1. The valve fittings of cylinders used to store different families of gases are different and will only allow regulators or needle valves to be attached that are safe for use with those gases. Cylinders must not be purchased or accepted whose fittings do not conform to standards of the National Compressed Gas Association. Use of adapters to connect regulators to cylinder valves defeats this safeguard and must not be used without written permission from Safety Services. Only pressure regulators and needle valves approved for the specific gases may be used.

2. Threads and points of unions must be clean and should be inspected before they are connected. Personnel must not attempt to lubricate threads or fittings.

3. When attaching regulators or needle valves, personnel must firmly tighten the connections. Nonadjustable wrenches of the proper size should be used. Pliers or adjustable wrenches should not be used as they damage the nuts, most of which are brass and rather soft. Need for excessive force often indicates that the regulators or needle valves do not fit the cylinders. Leaks at the unions between the regulators and the cylinder valves are usually due to damage to the faces of the connections. Attempts to force a tight fit may damage the previously undamaged half of the connection. If the cylinder valve faces are damaged, the cylinders must be returned to the vendor. Employees must not attempt to repair cylinders in regulators. Damaged regulators must not be used until repaired.

4. After attaching the pressure regulator to the cylinder, personnel should turn out the delivery pressure adjusting screw of the regulator until it turns freely. The cylinder valve should be opened slowly. Laboratory personnel should avoid standing directly in front of the regulator at any time as the pressure of the cylinder may blow out the glass face of a faulty gauge. The cylinder valve handle should be left attached to the valve while the cylinder is in use. A cylinder valve that “sticks” and does not open when the usual amount of force is applied, may be damaged. Personnel must not attempt to force it open, but should return the cylinder to the vendor, stating on the cylinder that the valve is stuck.

5. Pressure in full cylinders should be indicated on the cylinders or labels. Lack of full pressure may indicate leaks at the connections between the cylinders and valve regulators, damaged regulators, or incompletely filled cylinders.

6. Connect delivery lines to the low-pressure outlet of the regulator valve or to the needle valve. Where low-pressure lines are used, their valves should be closed, and the line pressure adjusted, by turning the regulator delivery pressure-adjusting screw until the desire pressure is shown on the delivery pressure gauge.

7. If the gases are not to be used over a considerable length of time (24 hours), the cylinder valves should be closed, the lines bled, and the pressure-adjusting screws turned back until they turn freely. Damage to gauges and inaccurate readings may result if pressure is left on the gauges during extended periods of non-use.

Leak Testing

Compressed gas cylinders are tested for leaks when they are filled. However, leaks have been detected when cylinders were received in laboratories. Personnel should not attempt to repair cylinder leaks or leaks caused by loose valve stem packing.

1. Leak testing using a soap solution should be performed twice. The first test should be made before the regulator or needle valve is attached to determine if there are leaks at the union of the cylinder and the cylinder valve, and to determine if the valve is leaking. The second test should be made after the regulator is attached and the cylinder valve is opened to detect leaks around the valve stem packing, the connecting fittings, the regulator or needle valve, or the transfer lines to the instrument.

2. Cylinders leaking nontoxic, nonflammable gas may be taken to a loading dock or other place having suitable airflow for regular and scheduled vendor pick-up. Leaks from cylinders of toxic or flammable gases require immediate attention and should be reported to Safety Services or

1. Laboratories shall perform periodic intensity testing of all UV installations. UV lamps in constant use should be replaced every six months. NOTE: UV lights often continue to emit blue light after effective energy output has fallen well below a useful range. Periodic monitoring with an appropriate light energy meter is necessary to verify proper output of UV light sources. Contact Radiation Safety (368.2906) to perform UV light monitoring.

2. UV lamps in air locks and door barriers will be turned on continuously. Skin or eye protection is not usually required for persons walking through these areas. Protection is required, however, for persons exposed to the

WORKING WITH BLOODBORNE PATHOGENS

The OSHA regulation known as The Bloodborne Pathogen Standard is intended to reduce occupational exposure to Hepatitis B (HBV), Human Immunodeficiency Virus (HIV), and other bloodborne pathogens. OSHA fully intends that, if

Z-LIST OF TOXIC SUBSTANCES

The following table lists toxic chemicals which are regulated by OSHA and have restrictions concerning their use.

Source: OSHA Standard 29 CFR 1910.1000: Table Z-1. Limits for Air Contaminants.

Check the chemical's MSDS for information on the following limits before beginning work:

1. **Permissible Exposure Limit (PEL)** – The term used by OSHA to indicate the maximum air concentration to which employees can be exposed during an 8-hour day on a regular basis. Exceeding these levels may result in additional duties, such as medical monitoring, or introduction of engineering controls to reduce air exposure levels.

2. **Threshold Limit Value (TLV)** – The term used by the American Conference of Governmental and Industrial Hygienists (ACGIH), an independent group, to indicate the time weighted average concentration (TLVTWA) for a normal 8-hour work day and a 40-hour work week, to which nearly all employees may be repeatedly exposed, day after day, without adverse exposure.

3. **Short-Term Exposure Limit (STEL or TLV-STEL)** – The concentration to which an employee can be exposed for no more than 15 minutes at a time, no more than 4 times a day. There must be at least 60 minutes between exposures at the STEL level.

4. **Ceiling (TLV-C)** – The highest concentration to which an employee can ever be exposed.

5. **SKIN** – ughv

Dimethyl 1,2-dibromo-2,2
dichloroethyl phosphate
Dimethylformamide
2,6-Dimethylheptanone
1,1-Dimethylhydrazine
Dimethylphthalate
Dimethyl sulfate
Dinitrobenzene (all isomers)
Dinitro-o-cresol
Dinitrotoluene
Dioxane
Diphenyl
Diphenylmethane
diisocyanate
Dipropylene glycol methyl ether
Di-sec-octyl phthalate
Emery
Endrin
Epichlorohydrin
EPN
1,2-Epoxypropane

Octane
Oil mist, mineral
Osmium tetroxide (as Os)
Oxalic acid
Oxygen difluoride
Ozone
Paraquat
Parathion
PCB
Pentaborane
Pentachloronaphthalene
Pentachlorophenol
Pentaerythritol

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

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

    b. After repeated skin application of less than 300 mg/kg of body weight per week.

    c. After oral dosages of less than 50 mg/kg of body weight per day.

Though many of these chemicals are in common use, they have been listed by the corresponding agency as being carcinogenic. The following is a list of

Substance	Source
benzidine	OSHA, IARC, NTP
benz[a]anthracene	IARC
benzidine-based dyes	IARC
benzo[a]pyrene	IARC
benzo[b]fluoranthene	IARC
benzo[j]fluoranthene	IARC
benzo[k]fluoranthene	IARC
benzofuran	IARC
benzotrichloride	NTP
benzyl violet 4B	IARC
beryllium and Be compounds	NTP, IARC
N,N-Bis(chloroethyl)-2-naphthylamine (Chlornaphazine)	IARC
bis(chloromethyl) ether and chloromethyl methyl ether(technical grade)	OSHA, IARC, NTP
bischloroethyl nitrosourea	NTP, IARC
bleomycins	IARC
bracken fern	IARC
bromodichloromethane	NTP, IARC
1,3-butadiene	IARC, NTP
1,4-butanediol dimethanesulfonate (myleran)	IARC, NTP
butylated hydroxyanisole	IARC, NTP
b-butyrolactone	IARC
cadmium and Cd compounds	NTP, IARC
caffeic acid	IARC
captafol	IARC
carbon black	IARC
carbon tetrachloride	NTP, IARC
ceramic fibers (respirable size)	NTP, IARC
chlorambucil	NTP, IARC
chloramphenicol	IARC
chlordane	IARC
chlordecone (kepone)	IARC
chlorendic acid	NTP, IARC
chlorinated paraffins (C12, 60% chlorine)	NTP
chlorinated toluenes	IARC

Substance	Source
dacarbazine	NTP, IARC
dantron	IARC
daunomycin	IARC
DDT	NTP, IARC
N,N'-diacetylbenzidine	IARC
2,4-diaminoanisole	IARC
2,4-diaminoanisole sulfate	NTP
4,4'-diaminodiphenyl ether	IARC
2,4-diaminotoluene	NTP, IARC
dibenz[a,h]acridine	IARC
dibenz[a,j]acridine	IARC
dibenz[a,h]anthracene	IARC
7H-dibenzo[a,h]carbazole	IARC
dibenzo[a,e]pyrene	IARC
dibenzo[a,h]pyrene	IARC
dibenzo[a,i]pyrene	IARC
dibenzo[a,l]pyrene	IARC
1,2-dibromo-3-chloropropane	OSHA, NTP, IARC
1,2-dibromoethane (ethylene dibromide)	NTP
1,4-dichlorobenzene	NTP, IARC
3,3-dichlorobenzidine	NTP, IARC
3,3-dichlorobenzidine and its salts	OSHA
3,3'-dichloro-4,4'-diaminodiphenyl ether	IARC
1,2-dichloroethane	NTP, IARC
dichloromethane (methylene chloride)	NTP, IARC
1,3-dichloropropene (technical grade)	NTP, IARC
dichlorvos	IARC
diepoxybutane	NTP, IARC
di(2-ethylhexyl)phthalate	NTP, IARC
diethylstilbestrol	NTP, IARC
diethyl sulfate	NTP, IARC
1,2'-diethylhydrazine	IARC
diglycidyl resorcinol ether	NTP, IARC
dihydrosafrole	IARC
diisopropyl sulfate	IARC
3,3-dimethoxybenzidine	NTP, IARC
3,3-dimethoxybenzidine 2HCl	NTP
4-dimethylaminoazobenzene	OSHA, NTP, IARC
trans-2-[(dimethylamino)methylimino]-5-[2-(5-nitro-2-furyl)vinyl]-1,3,4-oxadiazole	IARC
2,6-dimethylaniline	IARC
3,3-dimethylbenzidine	NTP, IARC
dimethylcarbamoyl chloride	NTP, IARC
dimethylformamide	IARC

Substance	Source
erionite	NTP, IARC

Reproductive Hazards

Reproductive toxins are chemicals or other hazards which may manifest themselves in lethal effects on the fertilized egg, developing embryo, or fetus, or have teratogenic effects in the fetus. In addition, certain reproductive toxins may cause infertility in males and females. The following is a list of chemicals which have been found to have at least one of the above effects. Source: Zenz C, Dickerson OB, Horvath EP. Reproductive toxicology and occupational exposure. Occupational Medicine St Louis: Mosby, 1994 .

Substance	**Effect**
acrylamide	decreased fertility
anesthetic gases (halogenated gases)	fetal effects
benzene, toluene, xylene	decreased fertility
boron	decreased fertility
cadmium	decreased fertility, fetal effects
carbaryl	decreased fertility
carbon disulfide	decreased fertility, increased menstrual bleeding
carbon monoxide	decreased fertility, fetal effects
chlordane and heptachlor	decreased fertility
chlordecone (kepone)	decreased fertility
1,2-dibromo-3-chloropropane (DBCP)	decreased fertility
dioxin	decreased fertility, fetal effects
epichlorohydrin	decreased fertility
ethylene dibromide (EDB)	decreased fertility, fetal effects
ethylene oxide	fetal effects
glycol ethers	decreased fertility, fetal effects
hexachlorobenzene (HCB)	fetal effects
ionizing radiation (x-rays and gamma rays)	decreased fertility, fetal effects

GLOVE COMPATIBILITY CHART

APPENDIX C

The following list contains brief guidelines for glove use with common chemicals. Refer to the glove manufacturer for additional details or if the chemical with which you are working is not on this list.

Latex gloves are not recommended for any laboratory procedure involving chemicals, as they do not provide adequate protection. Source: Adapted from the National Research Council, 1981.

GLOVE COMPATIBILITY CHART KEY:

E = Excellent protection
G = Good protection
F = Fair protection
P = Poor protection
-- = no available data

[a] Aromatic and halogenated hydrocarbons will attack all types of natural and synthetic glove materials. Should the gloves swell, the user should change to fresh gloves and allow the swollen gloves to dry and return to their normal state.

[b] No data is available on the resistance to dimethyl sulfoxide of neoprene, nitrile, or vinyl materials. The manufacturer recommends using butyl rubber gloves.

Chemical	Neoprene

TABLE OF CHEMICAL INCOMPATIBILITIES

The following list illustrates common laboratory chemical incompatibilities. Chemicals in both columns A and B should be kept separate from each other. This list is not intended to be exhaustive. Source: Adapted from the National Research Council, 1981.

*NOTE: Oxidizing agents include the types of compounds listed in the entry for alkali and alkaline earth metals, etc.

Column A	Column B
Acetylene and mono-substituted acetylenes	Groups IB and IIB metals and their salts; Halogens
Acids	Bases
Alkali and alkaline earth metals (including carbides, hydrides, hydroxides, oxides, and peroxides)	Water; Acids; Halogenated organic compounds; Oxidizing agents* (including chromates, dichromates, halogens, halogenating agents, hydrogen peroxide and peroxides, nitric acid, nitrates, perchlorates and chlorates, permanganates, and persulfates)
Ammonia, anhydrous and aqueous	Halogens; Halogenating agents; Silver; Mercury
Inorganic azides	Acids; Heavy metals and their salts; Oxidizing agents*
Inorganic cyanides	Acids; Strong bases
Inorganic nitrates	Acids; Metals; Nitrites; Sulfur
Inorganic nitrites	Acids; Oxidizing agents*
Inorganic sulfides	Acids
Mercury and its amalgams	Acetylene; Ammonia (anhydrous and aqueous); Nitric acid; Sodium azide
Nitric acid	Chromic acid and chromates; Metals; Nitrites; Reducing agents; Permanganates; Sulfides; Sulfuric acid
Organic compounds	Oxidizing agents*
Organic acyl halides	Bases; Organic hydroxy compounds
Organic anhydrides	Bases; Organic hydroxy compounds
Organic halogen compounds	Aluminum metal
Organic nitro compounds	Strong bases
Oxalic acid	Mercury and its salts; Silver and its salts
Phosphorus (yellow)	Oxygen; Oxidizing agents*; Strong bases
Phosphorus pentoxide	Halogenating agents; Water
Powdered metals	Acids; Oxidizing agents*
Sulfuric acid	Metals; Chlorates; Perchlorates; Permanganates; Nitric acid

APPENDIX D

SMALL SPILL CLEAN-UP GUIDELINES

Spills of many innocuous laboratory chemicals can be handled by laboratory personnel with appropriate procedures outlined below. If laboratory personnel have knowledge of the chemical(s) involved and can discern that the spill does not pose any hazards, clean-up may begin without the presence of Safety Services. If at any time there is doubt as to the nature or extent of the hazard, call Safety Services (368.2907). In University Hospitals

4. **Bromine** – Spilled bromine should be reacted with sodium thiosulfate solution (5%-10%). Under no circumstance should ammonium hydroxide be used, as an explosion may result upon mixing any of the halogens with ammonia. An appropriate respirator must be worn during clean-up.

5. **Acid Chloride** – Use calcined absorbent products, such as Oil-Dry, Zorb-All, or dry sand. Scoop the mixture into a plastic bag and dispose of properly.

6. **Hydrazines** – Avoid using anything contaminated with organic materials as an absorbent. Flush contaminated area with copious amounts of water.

7. **Alkali Metal** – The spilled metal should be smothered by using Met-L-X Yellow Extinguisher and removed to a safe location where it can be disposed of by reaction with a dry secondary alcohol (such as isopropanol) or by outdoor burning. Any metal particles splattered on the skin should be quickly removed, and the skin should then be flushed with water.

Arrange a follow-up survey with Safety Services to ensure the area is completely decontaminated. Safety Services will provide for proper waste disposal of any spilled or contaminated materials.

SELECT BIBLIOGRAPHY

Chemical	As broadly applied to the chemical industry, an element or a compound produced by chemical reactions on a large scale of either direct industrial and consumer use or for reaction with other chemicals.
Chemical Reaction	A change in the arrangement of atoms or molecules to yield substances of different composition and properties (see also Reactivity).
Chronic	Persistent, prolonged, or repeated conditions.
Chronic Exposure	A prolonged exposure occurring over a period of days, weeks, or years.
Combustible Liquid	According to DOT and NFPA, combustible liquids are those having a flash point at or above 100ºF, or liquids that will burn. They do not ignite as easily as flammable liquids. However, combustible liquids can be ignited under certain circumstances and must be handled with caution.
Concentration	The relative amount of a material in combination with another material. For example, 5 parts (of acetone) per million (parts of air).
Corrosive	A substance that, according to DOT, causes visible destruction or permanent changes in human skin tissue at the site of contact, or is highly corrosive to steel.
Cubic Meter (m^3)	A measure of volume in the International System (SI) of Units.
Cutaneous	Pertaining to, or affecting the skin.
Decomposition	The breakdown of a chemical or a substance into different parts of simpler compounds. Decomposition can occur due to wear, chemical reaction, decay, etc.
Dermatitis	An inflammation of the skin.
Designated Area	An area which may be used for work with select carcinogens, reproductive toxins, or substances with a high degree of acute toxicity (see Appendix B). A designated area may be the entire lab or a section of it, such as a chemical hood.

Flammable Liquid	According to DOT and NFPA, a liquid which has a flash point below 100ºF (see Flash Point).
Flammable Solid	A solid, other than a blasting agent or explosive as defined in 16 CFR 1910.109(s), that is liable to cause fire through friction, absorption or moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited, burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.45, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.
Flash Point	The lowest temperature at which liquid gives off enough vapor to form an ignitable mixture and burn when a source of ignition (spark, open flame, cigarette, etc.) is present. Two tests are used to determine flash point: Open cup and close cup. The appropriate test method is indicated on the MSDS.
General Ventilation	Also known as general exhaust ventilation. This is a system of ventilation consisting of either natural or mechanically induced fresh air movements to mix with and dilute contaminants in the workroom air. This is not the recommended type of ventilation to control contaminants that are highly toxic, when there may be corrosion problems from the contaminant being generated, and where fire or explosion hazards are generated close to sources of ignition (see also Local Exhaust Ventilation).
Hazardous Material	Any substance of compound that has the capability of producing adverse effects on the health and safety of humans.
Hematopoietic	Agents which act on the blood or the hematopoietic system. They decrease hemoglobin function and deprive the body tissues of oxygen. Signs and symptoms include cyanosis, loss of consciousness. Chemicals include carbon monoxide, cyanides.

Hepatoxins	Chemicals which produce liver damage. Signs and symptoms include jaundice, liver enlargement. Chemicals include carbon tetrachloride, nitrosamines.
Highly Toxic	a) A chemical that has a median lethal dose of 50 mg (LD50) or less per kg of body weight when administered orally to albino rats weighing between 200 g and 300 g each. b) A chemical that has an LD50 of 200 mg or less per kg Tc -0.001 Tc en eight w b)hen

Kilogram (kg)	A unit of weight in the International System (SI) of Units equal to 2.2 U.S. pounds.
Lethal Concentration 50 (LC50)	The concentration of a material in air that will kill 50% of the test subjects when administered as a single exposure (typically 1 or 4 hours).
Lethal Dose 50 (LD50)	The dose of a substance or chemical that will kill 50% of the test animals in a group during a single exposure.
Local Exhaust Ventilation	Also known as exhaust ventilation. A ventilation system that captures and removes the contaminants at the point they are being produced before they escape into the workroom air. The system consists of hoods, ductwork, a fan, and possibly an air-cleaning device. It works by removing the contaminant, not just diluting it, making it more economical over the long-term. However, the system must be properly designed with correctly shaped hoods, and correctly sized fans and ductwork.
Lower Explosive Limit (LEL) Also known as: Lower Flammable Limit (LFL)	The lowest concentration of a substance that will produce a fire or flash when an ignition source is present. It is expressed in the percent of vapor or gas in the air by volume. Below the LEL or LFL, the air/contaminant mixture is theoretically too “lean” to burn (see also UEL).
Lung Hazards	Chemicals which damage the lungs. Signs and symptoms include cough, tightness in chest, shortness of breath. Chemicals include silica, asbestos.

Mutagen	Anything that can cause a change (or mutation) in the genetic material of a living cell.
Narcosis	Stupor or unconsciousness caused by chemical exposure.
Nephrotoxins	Chemicals which produce kidney damage. Signs and symptoms include edma, proteinuria. Chemicals include halogenated hydrocarbons, uranium.
Odor Threshold	The minimum concentration of a substance at which a majority of test subjects can detect and identify the substance's characteristic odor.
Oxidation	The process of combining oxygen with some other substances of a chemical change in which an atom loses electrons.
Oxidizer	A substance that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.
Oxygen Deficiency	An atmosphere having less than the normal percentage of oxygen (20%) found in normal air.
Permissible Exposure Limit (PEL)	The term used by OSHA to indicate the maximum air concentration to which employees can be exposed. PEL may be given as an 8-hour time-weighted average (TWA) exposure limit, a 15-minute short-term exposure limit (STEL), or a ceiling (C).
Personal Protective Equipment (PPE)	Any device or clothing worn by the worker to protect -1(s),1c 0.and0030-1(s)-Tf 1T-n BT /TT1 1 Tf 0 -3 0 Tw 12 -0430 >>.0

Pyrophoric	A chemical that will ignite spontaneously in air at a temperature of 130ºF or below.
Reactivity	A substance's susceptibility to undergoing a chemical reaction or change that may result in dangerous side effects, such as explosions, burning, and corrosive or toxic emissions. The conditions that cause the reaction, such as heat, other chemicals, or dropping, will usually be specified as "Conditions to Avoid" when a chemical's reactivity is discussed on an MSDS.
Reproductive Toxins	Chemicals which affect the reproductive capabilities, including chromosomal damage (mutations), and effects on fetuses (teratogenesis). Signs and symptoms include birth defects, sterility. Chemicals include lead, 1,2-dibromo-3-chloropropane (DBCP).
Risk Assessment	Evaluation of existing hazards concerned with a procedure or process in the work environment.
Select Carcinogen	See Appendix B for full definition.
Short-Term Exposure Limit (STEL or TLV-STEL)	The maximum concentration to which an employee can be exposed for no more than 15 minutes at a time, no more than 4 times a day. There must be at least 60 minutes between exposures at the STEL level. The Time Weighted Average (TLV-TWA) must also not be exceeded.
SKIN	This designation sometimes appears on an MSDS alongside a TLV or PEL. It refers to the possibility of absorption of the particular chemical through the skin and eyes. Thus, protection of large surface areas of skin should be considered so that the Threshold Value Limit (TLV) is not invalidated.
Skin Hazards	Chemicals which affect the dermal layer of the body. Signs and symptoms include depletion of fats of the skin, rashes, irritation. Chemicals include ketones, chlorinated compounds.
Systemic	Spread throughout the body, affecting many or all body systems or organs not located in one spot or area.

Teratogen	An agent or substance that may cause physical defects in the developing embryo or fetus.
Threshold Limit Value (TLV)	Airborne concentrations of substances devised by the ACGIH that represent conditions under which it is believed that nearly all employees may be repeatedly exposed, day after day, without adverse effects. TLVs are advisory guidelines, not legal standards, that are based on evidence from industrial experience, animal studies, or human studies when they exist. TLVs include: Time Weighted Average (TLV-TWA), Short-Term Exposure Limit (TLV-STEL), and Ceiling (TLV-C) (see also PEL).
Time Weighted Average (TLV-TWA)	The average time over a given work period (e.g., an 8-hour work day) of a person's exposure to a chemical or agent. The average is determined by sampling for the contaminant throughout the work period.
Upper Explosive Limit (UEL) Also known as: Upper Flammable Limit (UFL)	The highest concentration of a substance that will burn or explode when an ignition source is present. It is expressed in the percent of vapor or gas in the air by volume. Above the UEL, or UFL, the air/contaminant mixture is theoretically too "rich" to support combustion. The difference between the LEL and the UEL constitutes the flammable range or explosive range of a substance. That is, if the LEL is 1 ppm and the UEL is 5 ppm, then the explosive range of the chemical is 1 ppm

GLOSSARY OF ORGANIZATIONS

ACGIH

NIOSH	The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness.
NIH	The National Institutes of Health is a biomedical research center comprised of 27 separate institutes and centers. The goal of the NIH research is to acquire new knowledge to help prevent, detect, diagnose, and treat disease and disability.
OSHA	The Occupational Safety and Health Administration is a Federal Agency under the Department of Labor which publishes and enforces safety and health regulations for most businesses and industries within the United States.