

UNIVERSITY OF TOLEDO



LABORATORY SAFETY AND HEALTH MANUAL AND INSTITUTIONAL CHEMICAL HYGIENE PLAN

Environmental Health and Radiation Safety Department
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EMERGENCY PHONE NUMBERS:

Fire	Pull Station / 911
Hazardous Materials Spills	419-530-2600 (MC) or 419-383-2600 (HSC)
Environmental Health and Radiation Safety Department	419-530-3600
Radiation Safety Office	419-383-4301

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SECTION I - FORWARD

This is intended as a reference manual and should not be relied on as a comprehensive listing of laboratory safety practices. Rather, this manual is intended to be a guideline for providing general laboratory health and safety information for staff, students and faculty.

The laboratory specific chemical hygiene plan developed by the principle investigator in the lab should be referred to for lab specific information.

SECTION II - PUBLIC EMPLOYEES RISK REDUCTION PROGRAM (PERRP) OSHA

On January 31, 1990, the Occupational Safety and Health Administration (OSHA) promulgated a final rule entitled Occupational Exposures to Hazardous Chemicals in Laboratories (commonly known as "The Laboratory Standard"). The basis for this standard is a determination that laboratories differ from industrial operations in their use and handling of hazardous chemicals and that a different approach than that found in OSHA's substance specific health standards is warranted to protect workers. In 1994, the Ohio Legislature adopted all of the federal OSHA regulations into Ohio law for all state and public employees. This standard does not establish new exposure limits, but requires the development of performance provisions designed to protect laboratory workers from potential hazards in their specific work environment. These performance provisions must be present in a plan called a Chemical Hygiene Plan and a Chemical Hygiene Officer must be assigned. This document acts as the Institutional Chemical Hygiene Plan and Timothy Niederkorn currently serves as UT's Chemical Hygiene Officer. A laboratory hygiene officer may be appointed by each lab's principle investigator. The principle investigator is responsible for ensuring laboratory specific information is included in the "Laboratory Specific Chemical Hygiene Plan" including standard operating procedures for toxic chemicals used in the lab.

The Laboratory Standard applies to all employees engaged in the laboratory use of hazardous chemicals and is defined as the use or handling of chemicals in which all of the following conditions are met:

- Chemical manipulations are carried out on a "laboratory scale." Laboratory scale is defined as work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. This definition excludes those workplaces whose function is to produce commercial quantities of materials.
- Multiple chemical procedures or chemicals are used.
- The procedures involved are not part of a production process, nor in any way simulate a production process.

SECTION III - LAB EQUIPMENT

USE AND HANDLING

The following provides information regarding the proper use, handling, safety features, and maintenance procedures for laboratory equipment.

Good equipment maintenance is important for safe, efficient operations. All equipment should be inspected and maintained regularly. Maintenance plans should include procedures to ensure that a device that is out of service cannot be restarted.

Proper equipment conditions include, for example:

Centrifuge rotors and tubes that are balanced and in good condition, without chips or flaws.

Oven temperature regulators *that have been periodically checked*, as required, to ensure they are working correctly.

Protective guards covering moving parts, gears, belts, pulleys, etc., on laboratory equipment and machinery.

BIOLOGICAL SAFETY CABINETS

Biological safety cabinets are considered primary barriers and are the principle devices used to provide containment of infectious aerosols. The three classes of biological safety cabinets are:

- Class I and Class II: Open-fronted partial containment cabinets used for protection from low to moderate risk etiologic agents.
- Class III: A gas tight (glove box) cabinet providing the highest level of containment from infectious aerosols.

In general:

- Biological safety cabinets are to be *recertified* annually in accordance with NSF Std. 49, when moved, after undergoing maintenance when used with BSL2 or higher level agents.
- All new biological safety cabinets are to be certified prior to use.
- **Biological safety cabinets shall not** be used as, or in place of, a chemical fume hood.
- Biological safety cabinets will not be plumbed for natural gas to allow for the operation of a bunsen burner inside of the unit. Biological safety cabinet filters, located just above the work surface, are combustible. Additionally, even small flames significantly disrupt protective airflows which can negate the protection the cabinet provides.

For information or assistance regarding biological safety cabinets, contact the Environmental Health and Radiation Safety Department.

DRYING OVENS

Electrically heated ovens are commonly used in the laboratory to remove water or other solvents from samples and to dry laboratory glassware.

- Ovens should not be used to dry any chemical sample that has even moderate volatility and might pose a toxicity hazard.
- Glassware that has been rinsed with an organic solvent should not be dried in an oven. First rinse with water before placing in the oven.
- Thermometers containing mercury should not be mounted through holes in the tops of ovens so the bulb of mercury hangs into the oven. Mercury thermometers should be eliminated wherever possible.
- Drying and warming units located under many fume hoods inside campus research labs must be disabled by Facilities Maintenance prior to the storage of any other materials in these units, especially flammable liquids.

REFRIGERATORS

Precautions recommended for the use of refrigerators center around the inability to vent the interior atmosphere.

- Laboratory refrigerators should never be used for the storage of food or beverages.
- Flammable liquids should never be stored inside a refrigerator unless its design is explosion proof.

FUME HOODS

Fume hoods provide a greater protection to faculty, staff, and students handling chemicals by capturing and exhausting chemical vapors and contaminants to the outside. The fume hood sash provides protection by the physical barrier it creates between the individual and the chemical reaction. Fume hoods are inspected and tested annually by Environmental Health and Radiation Safety to ensure they are in proper working order and should display a certification sticker indicating this.

Use the following guidelines:

- Eliminate the storage of excessive amounts of chemicals and equipment in the hood.
- Reduce cross-drafts by closing windows, doors, and minimizing movement around fume hood area.
- Work should be conducted in the center of the fume hood, at least six (6) inches from forward edge.
- Avoid excessive vapor release by frequently monitoring reactions.
- Refer to face velocity tags on front of fume hood for correct sash height necessary to achieve a *minimum/maximum 80-120 fpm face velocity*.
- Close the fume hood sash when not in use

For information or assistance regarding fume hoods, contact the Environmental Health and Radiation Safety Department.

BURNERS AND HEATING ELEMENTS

Do not leave lit gas burners unattended.

Burners should be turned off at the petcocks, NOT at the burner base.

DO NOT use or permit burners, hot plates, or non-explosion-proof motors near experiments which may generate flammable or combustible vapors.

Heating chemicals

Prevent splattering of liquid chemicals by placing boiling stones in vessels or by using a beaker cover. DO NOT USE TEST TUBES.

Use a thermometer in boiling liquids if there is a possibility that overheating or decomposition could produce undesirable results.

Use a metal dial type thermometer in drying ovens because a mercury thermometer can contaminate the oven when broken.

Use tongs of proper size and type when handling heated containers.

Experiments that can emit toxic, noxious, flammable, or harmful vapors MUST BE CONFINED TO A FUME HOOD.

Apparatus attached to a ring-stand should be positioned with the lowest center of gravity over the base, while leaving adequate room for removal of burners or baths.

HEATING DEVICES

(Hot plates, Mantles, Baths)

Heating elements should be enclosed in a glass, ceramic or insulated metal case such that contact with the wire carrying current is not possible.

When a device is to be left unattended for a significant period of time, it is recommended that it be equipped with a temperature sensing device that will turn off power if a certain preset temperature is reached.

ELECTRICAL EQUIPMENT

Because of the inherent hazards when working with electricity, the following procedures are provided to reinforce safe work methods:

- All electrical equipment must be grounded. Use either a three pronged plug or double insulation.
- All electrical service cords must be in good condition.
- Remove from service any equipment with frayed cords or exposed wires.
- All electrical repairs should be made by qualified personnel.
- Use a single plug for each electrical connection.
- Do not use multiple plugs for additional connections (octopuses).
- Permanent wiring should **never** be replaced by extension cords. Extension cords are prohibited from use in the laboratories.
- Do not overload circuits.
- Do not handle an electrical connection with *wet hands or when near or standing in water*.
- Electrical equipment, such as mixers or hot plates, should not be used near flammable solvents unless they are explosion-proof.
- Never bypass any safety device on a piece of electrical equipment.
- Never use "cheater" plugs

In case of an electrical fire use the following procedures:

Immediately alert everyone in the fire area.

Pull closest fire pull station and call 911.

To extinguish a blaze, use only a multi-purpose ABC, BC, or carbon dioxide (CO₂) extinguisher if the fire is small (trash can size) and you have been trained in its use.

STIRRING & MIXING DEVICES

The devices include stirring motors, magnetic stirrers, shakers and rotary evaporators.

These devices are frequently used inside a fume hood. It is important that, in an emergency, they be able to be turned off from outside the hood. It is important that they be operated in a way that precludes the production of sparks.

VACUUM PUMPS

Vacuum pumps are suitable for the distillation of relatively less volatile substances, removal of final traces of solvents, and similar operations that require lesser pressures than those created by a water aspirator.

Input lines should be fitted with a cold trap to collect volatile substances and prevent them from entering the vacuum pump and collecting in pump oil. When possible, cold traps should utilize dry ice/alcohol baths to prevent LoX accumulation hazard.

The introduction of mercury being swept into the line as a result of a sudden loss of vacuum can be minimized by placing a kjeldahl trap in line to the pump.

The output of each pump should be vented to an air exhaust system.

PLUMBING

To prevent malodors and possible flash fires caused from the escape of toxic and flammable sewer gases into the laboratory from sink traps and floor drains, keep traps and drains filled with water AT ALL TIMES.

CHEMICALS SHALL NOT BE Poured DOWN DRAINS. Chemical and biological wastes must be disposed of in accordance with Federal and Ohio EPA regulations.

Each laboratory water supply outlet must be equipped with either a vacuum breaker or a back-flow prevention device. No auxiliary plumbing should be connected to a water distribution line unless adequate back-flow prevention is provided.

VACUUM SYSTEMS

Adequate traps must be used in vacuum systems where mechanical pumps are used to prevent corrosion of the pump. *Do not release the vacuum* in any apparatus where the temperature is above 150°C. THE VAPORS MAY EXPLODE.

GLASS

Do not use broken, chipped, starred, or badly scratched glassware. Dispose of unusable glass in "broken glass only" containers. Broken glass containers should be in good condition and not weigh more than 35lbs when full. Disposal of broken glass containers should be arranged with environmental/building services. If the broken glass container is over 35lbs, or the container in in poor condition, researchers are responsible for transporting and disposing of the broken glass container into the dumpster.

If glassware is likely to shatter from pressure or vacuum, use a coated container or one surrounded by mesh or cloth to prevent the spraying out of glass particles.

For protection wrap a towel or cloth around glass bottles when removing stuck lid or stopper, and when cracking open ampules. NEVER OPEN AN AMPULE CONTAINING FLAMMABLE LIQUID BY HEATING THE TIP.

When inserting or removing GLASS TUBING from a stopper, protect hands by using gloves, towel, or tubing holder. Lubricate tubing with water or glycerin, and keep one hand on tubing, close to the stopper, and out of line with the end of the tube.

To prevent accidental breakage, keep glass apparatus away from edge of work areas.

Prevent cuts and abrasions from broken glass by using protective gloves to pick up larger pieces. Thoroughly sweep area.

Proper storage and handling of laboratory materials are essential for a safe environment and to maintain quality laboratory resources. The key to ensuring safety and quality is the conscientious regulation of all materials and adherence to proper operating procedures.

STERILIZERS/AUTOCLAVES

Sterilizer and rack/shelves will be hot after each cycle is run. Wear protective gloves and an apron when removing a processed load or when relocating the sterilizer following previous operation.

To avoid slippery floor conditions, immediately wipe up any spillage or condensation in the sterilizer loading area.

A steam supply malfunction may cause the sterilizer chamber to fill with scalding water. Do not open the chamber door if the unit fails to complete an automatic cycle or if water leaks past the door gasket upon unlocking the door.

To avoid personal injury or property damage from bursting bottles or hot fluid:

- Use liquids cycle only - no other cycle is safe
- Use only vented closures - no screw caps or rubber stoppers with crimped seal
- Use only type 1 borosilicate glass bottles
- Avoid sudden full opening of door at the end of cycle
- Do not allow hot bottles to be jolted - this can cause hot bottle explosions. Don't move bottles if any boiling or bubbling is present
- Allow bottles to cool to the touch before attempting to move them

Follow the safety instructions posted near the sterilizers. If a unit fails to operate, place an OUT OF ORDER sign on the unit and alert the Biomedical Engineering Department on the Health Science Campus at x4899 and Facilities Maintenance on the Main Campus at X1000 to report the malfunction.

MACHINE SHOP EQUIPMENT

The use of machine shop equipment is commonly found in research and requires specific training. The department in which the equipment resides is responsible for lab/equipment specific training, including a PPE hazard assessment and routine equipment inspections. A general machine shop training presentation has been developed and is located on the Environmental Health and Radiation Safety on-line test bank.

A machine shop lab survey has also been developed and will be used in lieu of the lab safety and health survey for all research based machine shops.

General Rules

1. Do not attempt to remove foreign objects from the eye or body. Medical Emergencies call 911. If chemicals get in the eye(s), wash eye(s) for 15 minutes in an open flow of water before proceeding for medical treatment.
2. Avoid excessive use of compressed air to blow dirt or chips from machinery to avoid scattering chips. Never use compressed air guns to clean clothing, hair, or aim the gun at another person.
3. Machines **must be shut off** when cleaning, repairing, or oiling.
4. Do not wear ties, loose clothing, jewelry, gloves, etc. around moving or rotating machinery. Long hair must be tied back or covered to keep it away from moving machinery. Hand protection in the form of suitable gloves should be used for handling hot objects, glass or sharp-edged items.
5. Wear appropriate clothing for the job.
6. Do not work in the shop if you are tired or in a hurry – this almost always ruins the work, and often results in injury.
7. Never indulge in horseplay in the shop areas.
8. All machines must be operated with all required guards and shields in place.
9. A brush, hook, or special tool is preferred for removal of chips, shavings, etc. from the work area. **Never** use your hands to clean cuttings – they are sharp!
10. Keep your fingers clear of the point of operation of machines by using special tools or devices, such as, push sticks, hooks, pliers, etc. **Never use a rag near moving machinery.**
11. A hard hammer should not be used to strike a hardened tool or any machine part. Use a softfaced hammer.
12. Keep the floor around machines clean, dry and free from trip hazards. Do not allow chips to accumulate.
13. **Think through the entire job before starting.** Ask for help if you have questions.
14. Before starting a machine, always check it for correct setup and always check to see if machine is clear by operating it manually, if possible.
15. Do not drink alcoholic beverages before or during work in the machine shop area. Do not bring food or snacks into the shop.
16. If you have not worked with a particular material before, check the hazardous materials safety data sheets for any specific precautions to be taken while working with the material. Also, ask the shop personnel before cutting any unusual material.
17. Heavy sanding and grinding should only be done in well-ventilated areas.
18. Follow all appropriate precautions when working with solvents, paints, adhesives or other chemicals. Use appropriate protective equipment.
19. Check the power cords and plugs on portable tools before using them.
20. Always store oily rags in an approved metal container.

SECTION IV - GENERAL SAFETY GUIDELINES

Know the hazards associated with the materials you are using. Carefully read the label before using a chemical. Review the Safety Data Sheet (SDS) for any special handling information. In some cases it may be necessary to do additional research. Information provided in this guide and references listed in Section XIII may help. Contact the Environmental Health and Radiation Safety Department at 419-530-3600, for assistance with the evaluation of hazards associated with a specific material.

Be prepared for hazardous material emergencies and know what action to take in the event of an emergency. Assure necessary supplies and equipment are available for handling small spills of hazardous materials.

- Know the location of safety equipment: emergency shower, eye wash, fire extinguisher, fire alarm pull station.
- If you are working with hazardous materials, do not work alone.
- Purchase the minimum amount of hazardous materials necessary to accomplish your work and dispense the minimum amount necessary for immediate use.
 - A. Storage of flammable liquids in excess of NFPA 45 guidelines is prohibited.
- Use hazardous chemicals only as directed and for their intended purpose.
- Never smell or taste a hazardous chemical.
- Inspect equipment or apparatus for damage before adding a hazardous chemical or beginning a hazardous procedure. Do not use damaged equipment.
- Assure ventilation is adequate for the materials you are using. Refer to the SDS for information on ventilation requirements or contact the Environmental Health and Radiation Safety Department. See the Engineering Controls Section XVI for information on the proper use of ventilation.
- Avoid direct contact with any chemical. Keep chemicals off your hands, face and clothing, including shoes.
- Use required personal protective equipment. See the Personal Protective Equipment Section XVIII for additional information.
- Label all secondary containers with appropriate GHS hazard information. Assure labels on primary and secondary containers do not become damaged. Replace them when necessary. Never attempt to use an unlabeled container.
- Use good hygiene. Keep your hands and face clean. Wash thoroughly with soap and water after handling any chemical.
- Smoking, use of other tobacco products or electronic cigarettes, eating, gum chewing, drinking, the application of cosmetics and lip balm, manipulation of contact lenses, and mouth pipetting is forbidden in all technical work areas and where hazardous chemicals are used.
- Electrically ground and bond containers using approved methods before transferring or dispensing a flammable liquid from a large container.
- Assure adequate storage facilities and containers are provided for hazardous materials. See the Chemical Storage Section for details on storage categories.
- For specific information regarding chemical handling, contact your supervisor, instructor or the Environmental Health and Radiation Safety Department at 419-530-3600.

A. GENERAL PROCEDURES AND PRECAUTIONS FOR WORKING WITH SUBSTANCES OF **MODERATE CHRONIC OR ACUTE HIGH TOXICITY**

Examples: diisopropylfluorophosphate, hydrofluoric acid, hydrocyanide

If properties of LD50 or LC50 are known, the following chart should be referenced:

**Toxicity Classes: Gosselin, Smith and Hodge
Probable Oral Lethal Dose (Human)**

Toxicity Rating or Class	Dose	For 70-kg Person (150 lbs)
6 - Super Toxic	Less than 5 mg/kg	1 grain (a taste - less than 7 drops)
5 - Extremely Toxic	5-50 mg/kg	4 ml (between 7 drops and 1 tsp)
4 - Very Toxic	50-500 mg/kg	30 ml (between 1 tsp and 1 fl ounce)
3 - Moderately Toxic	500-5000 mg/kg	30-600 ml (between 1 fl oz and 1 pint)
2 - Slightly Toxic	5000-15,000 mg/kg	600-1200 ml (between 1 pint to 1 quart)
1 - Practically Non-Toxic	Above 15,000 mg/kg	More than 1200 ml (more than 1 quart)

If toxicological properties of any of the substances being used or prepared in the lab are unknown, these procedures should also be followed.

Objective: Minimize the exposure of the lab worker to toxic substances, by any route of exposure, by taking all reasonable precautions.

1. Complete a Standard Operation Procedure using the form in Appendix C for chemicals with an LD50 of less than 50 mg/kg, skin LD50 <200mg, air LC50 <200ppm.
2. Protect the hands and forearms by wearing either gloves and lab coat or suitable long gloves to avoid contact of toxic material with the skin.
3. Procedures involving volatile toxic substances and solid or liquid toxic substances that may result in the generation of aerosols should be conducted in a hood or other type of containment device.
4. After working with toxic materials, wash the hands and arms immediately. Never eat, drink, smoke, chew gum, apply cosmetics, take medicine or store food in areas where toxic substances are being used.
5. Containers of toxic materials should be stored in pans or trays made of polyethylene or other chemically resistant material. Apparatus should be mounted above trays made of similar material.
6. Vapors discharged from apparatus should be trapped or condensed to avoid adding substantial amounts of toxic vapor to the hood exhaust air.
7. Areas where toxic substances are being used should have restricted access, and special warning signs should be posted if a special toxicity hazard exists.
8. Hazardous wastes must be disposed of through the Environmental Health and Radiation Safety Department.
9. Containers of wastes from experiments involving appreciable amounts of weak or moderate carcinogens should carry the warning: CANCER-SUSPECT AGENT.

A. GENERAL PROCEDURES AND PRECAUTIONS FOR WORKING WITH **ALLERGENS** AND **EMBRYOTOXINS**

Objective: Minimize the exposure of the lab worker to toxic substances, by any route of exposure, by taking all reasonable precautions.

1. Complete a SOP using the form in Appendix C if substance is a reproductive toxin.
2. Allergens (diazomethane, isocyanates, bichromates): wear suitable gloves to prevent hand contact with allergenic or substances of unknown allergenic activity.
3. Embryotoxins (organomercurials, lead compounds, formamide): If you a woman of child bearing age, handle only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel to prevent skin contact.
4. Review each of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.
5. Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.
6. Keep records of the amounts stored, used, dates of use, and names of users.
7. Notify supervisors of all incidents of exposures or spills; consult a qualified physician when appropriate.

A. GENERAL PROCEDURES AND PRECAUTIONS FOR WORKING WITH **CHEMICALS OF HIGH CHRONIC TOXICITY INCLUDING CARCINOGENS**

Objective: Minimize the exposure of the lab worker to toxic substances, by any route of exposure, by taking all reasonable precautions.

1. Complete a Standard Operation Procedure using the form in Appendix C (Dimethylmercury and nickel carbonyl, benzo-a-pyrene, N-nitrosodiethylamine, other human carcinogens or substances with high carcinogenic potency in animals).
2. Conduct all transfers and work with these substances in a designated area for which all people that have access to the area are aware of the substances being used and necessary precautions.
3. Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood. Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the designated area.
4. Decontaminate the designated area before resuming normal work. Use a wet mop if necessary.
5. On Leaving the area, remove and PPE and wash hands, forearms, face, and neck.
6. Keep records of the amounts stored, used, dates of use, and names of users.
7. Assure everything is LABELED!!!
8. Volatile substances having high chronic toxicity should be stored in a ventilated storage area in a secondary tray or container.
9. Containers' labels should clearly warn of the hazard of the material contained, such as: WARNING: HIGH CHRONIC TOXICITY HAZARD OR CANCER-SUSPECT AGENT.
10. Proper gloves (selected based on their permeability) should be worn when transferring or otherwise handling substances. In some cases, it may be advisable to use other protective apparel, such as an apron. Such additional precautions might be called for, for example, when handling large amounts of certain heavy metals and their derivatives or compounds known to be potent carcinogens.

B. GENERAL PROCEDURES AND PRECAUTIONS FOR **ANIMAL WORK WITH CHEMICALS OF HIGH CHRONIC TOXICITY**

Objective: Minimize the exposure of the lab worker to toxic substances, by any route of exposure, by taking all reasonable precautions.

1. Complete a Standard Operation Procedure using the form in Appendix C and a chemical addendum through the IACUC process.
2. Administer agent in DLAR.
3. When possible administer substance by injection or gavage instead of in the diet. If administration is in diet, use a caging system under negative or under laminar flow directed toward HEPA filters.
4. Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces.
5. Wear proper PPE as defined by the animal protocol.
6. Disposal of all animal waste is done through DLAR.

C. GENERAL PROCEDURES AND PRECAUTIONS FOR WORKING WITH HEAVY METALS

Objective: Minimize the exposure of the lab worker to toxic substances, by any route of exposure, by taking all reasonable precautions.

1. If possible, substitute the heavy metal for a less hazardous material. If heavy metals must be manipulated, utilize forms that are in suspension.
2. Complete a Standard Operation Procedure using the form in Appendix C (Arsenic, Cadmium, Chromium, Lead, Mercury, Thallium, etc.).
3. Designate a work area for the use of heavy metals.
4. Whenever possible manipulate metal inside of a chemical exhaust hood whose satisfactory performance has been confirmed.
5. Devise procedures which minimize formation and dispersal of metal containing aerosols.
6. Clean the work area utilizing a HEPA vacuum or wet cleaning method after each use of the material and at least daily.
7. Prohibit dry sweeping and cleaning using compressed air.
8. Use appropriate personal protective equipment including use of disposable gloves and a lab coat, at a minimum.
9. Prohibit reusing disposable personal protective equipment.
10. Wash hands thoroughly after each use of heavy metals utilizing soap and hot water.
11. Collect hazardous wastes generated, as applicable, for disposal via EHRS.

D. RECORDKEEPING

RECORDS AND RECORDKEEPING

There are several repositories for records relevant to the OSHA Laboratory Standard. OSHA recordkeeping requirements are given in 29 CFR 1910.20. Included in those requirements is the maintenance of air monitoring results, accident reports, exposure assessments and medical consultations and examinations for at least 30 years. Records must be made accessible to employees or their representatives. All of the following are recordkeeping requirements of OSHA and UT.

DEPARTMENTAL RECORDKEEPING

Chemical Hygiene Plan
Departmental Specific Training Attendance Records
Chemical Inventory
Safety Data Sheets or equivalent reference

ENVIRONMENTAL HEALTH AND RADIATION SAFETY DEPARTMENT RECORDKEEPING

Area and personal air monitoring results
Exposure assessments
Laboratory safety inspections
Health and safety complaints
Institutional Training Attendance Records
Medical Surveillance information

E. LAB SURVEYS

Surveys shall be conducted in the laboratories at the University of Toledo to monitor current health and safety conditions on a regular basis, upon request, and when required due to safety and health concerns. The Department of Environmental Health and Radiation Safety will monitor violations and implement any necessary educational programs or policies that may rectify these reoccurring problems. Records of the survey will be maintained by the Department of Environmental Health and Radiation Safety for a period of one year.

Routine walkthroughs of each research and clinical lab are completed on a regular basis to identify commonly found environmental, safety and health concerns. In addition, clinical labs are surveyed twice yearly through environmental rounds. Full Scale laboratory surveys of research laboratories are completed as needed.

FULL SCALE LAB SURVEY PROCESS

1. Laboratory hygiene officers and principal investigators are notified in advance of full scale surveys and given the option of being present during the survey. A "Laboratory Survey Questionnaire" is completed by Environmental Health and Radiation Safety during the survey.
2. A report is generated and sent via email to the lab hygiene officer with a copy to the principal investigator indicating current laboratory safety and health issues and needed corrective actions.
3. The principal investigator is responsible for all corrective actions identified during the survey.

FAILURE TO CORRECT DEFENCIES AND ASSOCIATED LAB CLOSURE

In the event that a laboratory fails to correct issues identified by routine walkthroughs or full scale laboratory survey process, EHRS maintains the authority to initiate the lab closure process, as described below.

1. The researcher, associated chair and Vice President of Research will be notified via email and informed of the initiation of the lab closure procedure. Included will be:
 - a. A copy of the most recent survey detailing significant non compliance
 - b. A timeline for closure which will be dependant on the severity of the issues found but will not exceed 30 days.
 - c. Specific steps that the researcher or department can take to abate the identified issues.
2. EHRS will re-survey the laboratory at the end of the identified period.

3. If identified issues remain unabated, EHRS will:
 - a. Work with department staff to stabilize any ongoing reactions.
 - b. Limit access to the laboratory to EHRS personnel by changing lock cores or eliminating electronic access.
 - c. Communicate, via email, to the researcher, associated chair and Vice President of Research of the failure to abate identified hazards and access limitation.

Note: Environmental Health and Radiation Safety will refuse to sign off on any pending grants or protocols if unresolved issues exist in the laboratory.

G. MEDICAL SURVEILLANCE

Medical consultations and examinations may be required.

Please refer to <http://www.utoledo.edu/depts/safety/docs/HM-08-016.pdf>.

Illness/injury information resulting from an exposure or accident on the job must also be reported by completing the University of Toledo Injury/Illness form found at http://www.utoledo.edu/depts/safety/docs/Misc/EmployeeInjuryIllnessForm_with.doc.

Needlesticks can also occur in the laboratory setting. Please follow the Exposure Control Procedures found at http://www.utoledo.edu/depts/safety/docs/Hospital_EP/OCCUPATIONAL%20EXPOSURE%20FLOWCHART%20FOR%20CLINICS.pdf in the event of an exposure to blood or other potentially infectious materials.

H. TRAINING

The University of Toledo Department of Environmental Health and Radiation Safety requires initial and annual laboratory safety training for staff, students, faculty and volunteers. Users can complete trainings online by visiting <https://testbank.utoledo.edu/Public/Login.aspx>. The Principal Investigator(s) of the laboratory are responsible for ensuring that all laboratory personnel are compliant with this procedure. Principal Investigators are additionally responsible to ensure that laboratory staff and students have been trained on hazardous chemicals, potentially hazardous processes and laboratory specific hazards. This training should be refreshed regularly and records kept for the duration of the student or employees term with the laboratory.

SECTION V - HAZARDOUS CHEMICALS

The Hazard Communication Standard defines a hazardous chemical as any chemical which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified.

A chemical is a **health hazard** if the chemical is classified as posing one of the following hazardous effects:

- Acute Toxicity (any route of exposure)
- Skin Corrosion or Irritation
- Serious Eye Damage or Eye Irritation
- Respiratory or Skin Sensitization
- Germ Cell Mutagenicity
- Carcinogenicity
- Reproductive Toxicity
- Specific Target Organ Toxicity (Single or Repeated Exposure)
- Aspiration Hazard

A chemical is a **physical hazard** if the chemical is classified as posing one of the following hazardous effects:

- Explosive
- Flammable (gases, aerosols, liquids, or solids)
- Oxidizer (liquid, solid, or gas)
- Self-Reactive
- Pyrophoric (liquid or solid)
- Self-Heating
- Organic Peroxide
- Corrosive to Metal
- Gas Under Pressure
- In contact with water emits flammable gas

CHEMICAL SPECIFIC STANDARD OPERATING PROCEDURES

Provisions for additional employee protection for work with more toxic chemicals are required. These chemicals include **“select carcinogens”, reproductive toxins, pyrophorics and substances which have a high degree of acute toxicity. For these chemicals, you must establish a designated area of use and keep a copy of the “toxic chemical standard operating procedures” with your lab specific chemical hygiene plan located in your lab.** Several SOPs are located on the Environmental Health and Radiation Safety webpage. <http://www.utoledo.edu/depts/safety/>

This is not an exhaustive list of standard operating procedures. They serve as guides for common lab reagents. The SOP sample (found in Appendix C) must be completed for all toxic chemicals that do not already have a standard operating procedure. If you are not sure of the hazards of chemical(s) that you use, review the Material Safety Data Sheet (SDS) or contact the Environmental Health and Radiation Safety Department at 419-530-3600.

A chemical is considered **“select carcinogen”** if it is so identified in any of the following:

- Regulated by OSHA as a carcinogen
- Listed under the category “known to be carcinogen” in the National Toxicology Program, "Annual Report of Carcinogens" (latest edition)
- Listed in the International Agency for Research on Cancer, "Monographs" (latest edition) as “carcinogenic to humans (Group 1)” or “reasonably anticipated to be carcinogens (Group 2A and 2B).”

Examples:	Acrylamide	Diozane
	Benzene	Formaldehyde
	Chloroform	Styrene
	Vinyl Chloride	

A chemical that falls under the classification of “**reproductive toxins**” will be identified on the SDS as:

- Reproductive toxin
- May cause genetic damage
- Mutagenic
- Mutagen

Examples:	Benzene	Toluene
	Ethidium Bromide	Xylene

Chemicals that fall under the classification of “**substances with a high degree of acute toxicity**” will be identified on the SDS as:

- NFPA or HMIS Health Rating of 3 or 4
- Oral LD50 less than 50 mg/kg
- Skin LD50 less than 200 mg/kg
- Air LC50 = 200 ppm

Examples:	Acrolein	Chlorine
	Arsine	Hydrogen Cyanide

SECTION VI - HEALTH HAZARDS

For many hazardous materials, industrial hygiene standards have been established and action must be taken to assure personnel do not receive exposures in excess of these standards. These standards may be referred to as threshold limit values (TLVs) or permissible exposure limits (PELs). For specific information on the terms TLV or PEL, refer to the glossary in Section XXII.

The SDS will list the industrial hygiene standard for the hazardous chemical or each component of a mixture. In addition, the Environmental Health and Radiation Safety Department has a complete listing of published TLV's and PEL's and other works concerning the subject of industrial toxicology. If you would like to conduct a more thorough review of a particular compound or if you would like an evaluation of the exposure to a specific material used in your work area, contact the Environmental Health and Radiation Safety Department. Environmental Health and Radiation Safety will conduct air monitoring as needed.

For a detailed discussion on health hazards and those associated with specific chemicals refer to the Industrial Toxicology Section XV.

A. Nanomaterials

Nanotechnology is an emerging field. As such, there are many uncertainties as to whether the unique properties of engineered nanomaterials also pose occupational health risks.

"Engineered Nanomaterials" are intentionally created (in contrast with natural or incidentally formed) with dimensions <100 nanometers. This definition excludes biomolecules (proteins, nucleic acids, and carbohydrates). The Environmental Health and Radiation Safety Department has developed and implemented safe work practices for research involving engineered nanomaterials. Please review "Nanotechnology Safe Work Practices" (HM-08-038) at <http://www.utoledo.edu/depts/safety/docs/HM-08-038.pdf>.

If you use engineered nanomaterials please complete the following survey [Engineered Nanomaterial Survey](#). Environmental Health and Radiation Safety will contact the PI to set up an initial meeting to get a well-defined description of the work and to identify recognized and suspected hazards. Specific hazard control options will be recommended based on the results of the initial meeting. The effectiveness of the hazard controls in place may be quantitatively validated for suspect emissions using a variety of sampling techniques.

SECTION VII - PHYSICAL HAZARDS

Materials which present a physical hazard can be used safely if the specific hazards are understood and measures are taken to address the hazards. If appropriate action is not taken, the end result may be a fire, an explosion, unwanted corrosion, or unwanted pressure buildup and release resulting in harm or potential for harm to personnel and/or damage to property. The University of Toledo requires PI's to develop Standard Operating Procedures for potentially hazardous processes commonly used in the research laboratory. Some examples of potentially hazardous processes include pressurization of closed vessels (use of ACE reactors, Schlenk Lines) and distillate processes (THF drying).

Certain chemicals cannot be safely mixed or stored with other chemicals because a severe reaction can take place or an extremely toxic reaction product can result. See the Chemical Storage Section XIX for tables of incompatible chemicals.

The following is a description of the categories of physical hazards with information on special precautions for handling materials in these categories. These precautions are a supplement to the general precautions for handling of hazardous materials provided in the General Safety Procedures sections.

A. FLAMMABLE/COMBUSTIBLE MATERIALS

These are materials which under standard conditions can generate sufficient vapor to cause a fire in the presence of an ignition source. Flammable materials can generate sufficient vapors at temperatures below 100°F (38°C) and below 200°F (93.3°C). There is a lower concentration limit of vapor (Lower Explosion Limit or LEL) that must be reached before the mixture becomes ignitable. For instance, the following are lower limits for some substances in air (values are percent by volume):

acetone	2.5	ethyl alcohol	3.2
benzene	1.4	hydrogen	4.0
carbon disulfide.....	1.2	octane	0.9
diethyl ether	1.8	propane.....	2.1

Considering the whole air space available, these numbers may seem fairly high. However, a flammable atmosphere need only build up in the immediate vicinity of an ignition. If an explosion occurs, it will almost certainly start a fire in the main body of the material which will spread and also disperse the material. There is also an upper explosive concentration (Upper Explosion Limit or UEL) where the mixture becomes so fuel-rich that it will not ignite but this is not normally encountered.

The vapors of these materials are invisible, and a vapor trail to an ignition source away from the immediate area can result in a flashback. Flammables are more hazardous at elevated temperatures due to more rapid vaporization. In addition, flammable and combustible materials react with oxidizers which can result in a violent fire or explosion.

The flammability of materials is measured by a flashpoint test. The flashpoint is the lowest temperature at which a liquid evolves vapors of sufficient quantity to ignite. So it stands to reason that, the lower the flashpoint of a given flammable material the greater the possibility of ignition and combustion. A classification of flammables and combustibles more closely reflecting the degree of personal hazard has been developed by a United Nations committee of experts. This classification divides substances into three flashpoint ranges:

Low flashpoint group: substances having a flashpoint below -18°C (0°F) [closed cup method], which are regarded as presenting a great danger. Included in this group are:

acetal	cyclopentane	gasoline
acetaldehyde	diethylether	hexane
cyclohexane	ethylamine	propionaldehyde
cyclohexene	furan	tetrahydrofuran

Intermediate flashpoint group: substances having a flashpoint from -18°C (0°F) to 23°C (73°F), which are regarded as presenting a medium danger. Included in this group are:

acrylonitrile	ethanol	propanol
alkylamines	ethyl acetate	toluene
benzene	methanol	xylenes

High flashpoint group: substances having a flashpoint from 23°C (73°F) to 61°C (141°F), which are regarded as presenting minor danger. Included in this group are:

amyl nitrate	dibromobenzene	hydrazine
bromobenzene	formalin	nitroethane
butanol	furfural	turpentine

Special Precautions for Safe Handling of Flammables and Combustibles

1. Eliminate ignition sources such as open flames, smoking materials, hot surfaces, sparks from welding or cutting, operation of electrical equipment, and static electricity. Post conspicuous "No Smoking" signs in the areas where flammable materials are used or stored.
2. Flammable substances should never be heated by using an open flame. Preferred heat sources include steam baths, water baths, heating mantles or hot air baths.
3. Minimize the quantity kept in the work area.
4. Store in approved flammable liquid containers (safety cans) and storage cabinets, or in a special storage room designed for that purpose. Store away from oxidizers (inorganic acids).
5. Flammable liquids stored in glass containers shall not exceed 1 quart. Exception: For conditions where chemical purity must be protected, flammable liquids stored in glass containers shall not exceed 1 gallon.
6. Refrigerators and freezers used for storage of flammables must be of explosion safe, explosion proof or intrinsic safe type. These units must have a UL or FM label certifying same.
7. Assure there is proper bonding and grounding when it is required, such as when transferring or dispensing a flammable liquid from a large container or drum. Assure bonding and grounding is checked periodically.
8. Ventilation is one of the most effective ways to prevent the formation of flammable mixtures. An exhaust hood should be used whenever appreciable quantities are transferred from one container to another, allowed to stand in open containers or heated in open containers.
9. Assure that all staff are trained in emergency procedures.
10. Assure appropriate fire extinguishers are in the area and that only those trained to use them do so.

B. CORROSIVES

These are materials which can react with the skin causing burns similar to thermal burns, and/or which can react with metal causing deterioration of the metal surface. The name or structure of a chemical alone is insufficient to identify a substance as a corrosive. For example, strong acids are corrosive (in its use here, "strong" is a technical term meaning highly ionized), but that is not to say that all acids are corrosives. Boric acid, for instance, is used as a component of some eyewash solutions. Information on whether a compound is a corrosive, is ultimately determined through third party experimentation, and will be recorded on the label and SDS for the given material. As a general guideline, however, acids and bases are corrosives and should be handled with care. Some common corrosives are:

aluminum chloride	hydrochloric acid	phosphorus pentoxide
benzoyl chloride	hydrofluoric acid	potassium hydroxide
bromine	nitric acid	sodium hydroxide
chromic acid	perchloric acid	sulfuric acid
hydrazine hydrate	phenyl trichlorosilane	trichloroacetic acid

Special Precautions for Handling Corrosives

1. Containers and equipment used for storage and processing of corrosive materials should be corrosion resistant.
2. Eye protection and rubber gloves should always be used when handling corrosive materials. A faceshield, rubber apron, and rubber boots may also be appropriate, depending on the work performed.
3. When mixing concentrated acids with water, add the acid slowly to water. **Never add water to acid.**
4. Acids and bases should be stored separately from each other. Organic acids should be stored with flammable materials, separate from oxidizers including oxidizing acids (inorganic acids). Oxidizing acids should never be stored with any combustible material.
5. An eyewash and safety shower must be readily accessible to areas where corrosives are used and stored. In the event of skin or eye contact with corrosives, immediately flush the area of contact with cool water for at least 15 minutes, remove all affected clothing and seek medical attention.
6. Certain weak acids (pH 5-11.9) can be poured down the sink when followed by copious amounts of fresh water after obtaining approval from Environmental Health and Radiation Safety.

C. OXIDIZERS

These are materials which react with other substances by giving off electrons and undergoing reduction. In other words, they release oxygen when they react, thus providing a self-contained source of energy to fuel a reaction. This reaction may result in fire or explosion, depending on the other reactants. For instance, when combining it with combustible materials, oxidizers will burn fiercely; with reactive substances, oxidizers may cause immediate combustion or explosion. **Oxidation reactions are the most frequent cause of chemical accidents.**

The NFPA Code for Storage of Liquid and Solid Oxidizing Materials, NFPA 43A-1980, defines oxidizing material, four classes of oxidizers and establishes requirements based on quantities. The four classes are:

Class 1 - An oxidizing material whose primary hazard is that it may increase the burning rate of combustible material with which it comes in contact. The standard applies when quantities are stored in excess of 4000 lb (1816 kg).

Class 2 - An oxidizing material that will moderately increase the burning rate of which may cause spontaneous ignition of combustible material with which it comes in contact. Regulated when stored in quantities in excess of 1000lb (454kg).

Class 3 - An oxidizing material that will cause a severe increase in the burning rate of combustible material with which it comes in contact with will undergo vigorous self-sustained decomposition when catalyzed or exposed to heat. Regulated when stored in quantities in excess of 200lb (91 kg).

Class 4 - An oxidizing material that can undergo an explosive reaction when catalyzed or exposed to heat, shock or friction. Regulated when stored in quantities in excess of 10lb (4.5 kg).

Some examples in the different classes are:

<p>Class 1</p> <p>aluminum nitrate ammonium persulfate barium chlorate barium nitrate barium peroxide calcium chlorate calcium nitrate calcium peroxide cupric nitrate hydrogen peroxide solutions, over 8% but not exceeding 27.5% concentration by weight lead nitrate lithium hypochlorite lithium peroxide magnesium nitrate magnesium perchlorate magnesium peroxide nickel nitrate nitric acid, 70% concentration or less perchloric acid solutions, less than 60% by weight potassium dichromate potassium nitrate potassium persulfate silver nitrate sodium carbonate peroxide sodium dichloro-s-triazinetriene dihydrate sodium dichromate sodium nitrate sodium nitrite sodium perborate sodium perborate tetrahydrate sodium perchlorate monohydrate sodium persulfate strontium chlorate strontium nitrate strontium peroxide thorium nitrate uranium nitrate zinc chlorate zinc peroxide</p>	<p>Class 2</p> <p>calcium hypochlorite, 50% or less by weight chromium trioxide (chromic acid) halane (1,3-dichloro-5,5-dimethyl hydantoin) hydrogen peroxide, 27.5% to 52% concentration by weight nitric acid, more than 70% concentration potassium permanganate sodium chlorite, 40% or less sodium peroxide sodium permanganate trichloro-s-triazinetriene (trichloroisocyanuric)</p> <p>Class 3</p> <p>ammonium dichromate hydrogen peroxide, 52 to 91% concentration by weight calcium hypochlorite, more than 50% by weight perchloric acid solutions, 60 to 72.5% by weight potassium bromate potassium chlorate potassium dichloro-s-triazinetriene (potassium dichloroisocyanurate) sodium chlorate sodium chlorite, over 40% by weight sodium dichloro-s-triazinetriene (sodium dichloroisocyanurate)</p> <p>Class 4</p> <p>ammonium perchlorate ammonium permanganate guanidine nitrate hydrogen peroxide solutions, more than 91% by weight perchloric acid solutions, more than 72.5% by weight potassium superoxide</p>
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Special Precautions for Safe Handling of Oxidizers

1. Know the reactivity of the materials involved in the experiment or process. Assure there are no extraneous materials in the area which could become involved in a reaction.
2. If the reaction can be violent or explosive, use shields or other methods for isolating the materials or the process.
3. Use the minimum amounts necessary for the procedure. Do not keep excessive amounts of the material in the vicinity of the process.
4. Store properly, away from organic materials, flammable materials and reducers.

D. WATER REACTIVE MATERIALS

These are materials which react with water to produce a flammable or toxic gas, or other hazardous condition: often a fire or explosion results. Examples of water-reactives include alkali metals such as lithium, sodium and potassium, acid anhydrides and acid chlorides.

Special precautions for safe handling will depend on the specific material and the conditions of use and storage. Contact the Environmental Health and Radiation Safety Department for information on the safe use of a specific material.

E. PYROPHORIC MATERIALS

These are materials which ignite spontaneously in air below 130°F (54°C). Often the flame is invisible. Examples of pyrophoric materials are t-butyl lithium, silane, silicon tetrachloride, and white or yellow phosphorus. Pyrophorics should be used and stored in inert environments. When inert environments are not available or suitable, appropriate PPE, including flame resistant coats and chemical protective gloves should be utilized. Laboratory PI's and Managers must develop and utilize a standard operating procedure (SOP) based on best-practices for manipulation (especially transfer) of pyrophoric materials before beginning work. New users to the developed SOP should be trained, observed using a non-hazardous substance and then have training documented in the space provided by the principal investigator on the SOP before being allowed to manipulate the pyrophoric material. An example SOP for working with liquid phase pyrophoric materials can be found at <http://www.utoledo.edu/depts/safety/labsafety.html>. The planned use of pyrophoric gases requires specialized engineering controls and monitoring systems. EHRS must be contacted before pyrophoric gases are purchased.

Examples of pyrophoric materials subject to this procedure include:

Alkylaluminum reagents

Alkyl lithium reagents

Alkenyllithium and Aryllithium reagents

Alkynyllithium reagents

Alkylzinc reagents

Boranes

Grignard Reagents (RMgX)

Partially or fully alkylated derivatives of metal and nonmetal hydrides (diethylaluminum hydride, diisobutylaluminum hydride, dichloro(methyl)silane)

Alkylated metals (butyllithium, triethylboron, trimethylaluminum)

Non-metal alkyls: R₃B, R₃P, R₃As; Tetramethylsilane, Tributylphosphine"

Metal alkyls and aryls, such as RLi, RNa, R₃Al, R₂Zn

Solids:

Alkali metals (lithium, sodium, potassium, sodium potassium alloy, cesium and rubidium)

Alkylated metal alkoxides or halides (dimethylaluminum chloride, diethylethoxyaluminum)

Finely divided metals (bismuth, calcium, hafnium, iron, magnesium, titanium, uranium, zirconium) Al, Co, Fe, Mg, Mn, Pd, Pt, Ti, Sn, Zn, Zr

Low valent metals (titanium dichloride)

Metal hydrides (potassium hydride, sodium hydride, lithium aluminum hydride, uranium trihydride NaH, LiAlH₄)

Nonmetals (white phosphorous)

Metal carbonyls (dicobalt octacarbonyl, nickel carbonyl) Ni(CO)₄, Fe(CO)₅, Co₂(CO)₈

Used hydrogenation catalysts, e.g. Raney Ni, are especially hazardous due to adsorbed hydrogen gas

Copper fuel cell catalysts, e.g. Cu/ZnO/Al₂O₃ Methanetetellurol (CH₃TeH)

Finely divided Iron sulfides (FeS, FeS₂, Fe₃S₄), Potassium sulfide (K₂S), Aluminum phosphide (AlP)" UCLA

Gases:

Nonmetal hydrides (arsine, boranes, germane, phosphine, silane) (Most of these are actually gases.)

B₂H₆ and other boranes, PH₃, AsH₃

University of Minnesota. (n.d.). Appendix C. List of Pyrophoric Materials. Retrieved February 3, 2017, from <http://www.dehs.umn.edu/PDFs/PyrophoricMaterialsListAppendix.pdf>

F. PEROXIDIZABLES

These are materials which react with oxygen to form peroxides which can explode with impact, heat or friction (i.e. removing a lid). Since these chemicals are packaged in an air atmosphere, peroxides can form even though the containers have not been opened. As a class, organic peroxides are even more shock sensitive than explosives such as TNT or picric acid. Even in small amounts these should not be stored under long-term normal conditions because of the tendency to decompose both slowly and uncontrollably. Small amounts must be refrigerated for the short time before use and then destroyed adequately before disposal. An excellent review of structure types, limits of storage, conditions of storage, and procedures for testing and removal of peroxide from many peroxidizable compounds has been published in the *Journal of Chemical Education* (see the following Table). Examples of peroxide formers include diethyl ether, dimethyl ether, and diethylene glycol.

Table 1 - Examples of Peroxidizable Compounds

Red Label <i>Peroxide Hazard on Storage Discard After 3 Months</i>	Yellow Label <i>Peroxide Hazard on Concentration Discard After 1 Year</i>	Yellow Label <i>Hazardous to Peroxide Initiation of Polymerization^a Discard After 1 Year</i>
isopropyl ether vinylidene chloride sodium amide divinyl acetylene potassium metal	Acetal Cyclohexene diethyl ether dicyclopentadiene dioxane decahydronaphthalene (Decalin) diacetylene ethylene glycol dimethyl ether methyl acetylene tetrahydrofuran vinyl ethers tetrahydronaphthalene (Tetralin)	methyl methacrylate chlorotrifluoroethylene styrene vinyl acetylene acrylic acid vinyl acetate acrylonitrile butadiene tetrafluoroethylene vinyl chloride vinyl pyridine chloroprene

^aunder conditions of storage in the liquid state the peroxide-forming potential increases and certain of these monomers (especially butadiene, chloroprene, and tetrafluoroethylene) should then be considered as Red-Label compounds.

Special Precautions for Handling Peroxidizables

1. Date all peroxidizables upon receipt and upon opening. Unless an inhibitor has been added by the manufacturer, materials should be properly disposed of after 18 months from date of receipt or 3 months from date of opening.
2. Researchers may opt to test for the presence of peroxides. Testing should occur at the time of opening and continue at least monthly using colorimetric testing strips. Solvents with detectable levels of peroxides should be immediately wasted via EHRS.
3. Do not open any container which has obvious crystal formation around the lid. **Call 419-530-2600 (University of Toledo Police Department) immediately to reach EHRS.**
4. Metal spatulas should not be used to handle peroxides because contamination by metals can lead to explosive decomposition. Ceramic or wooden spatulas may be used.
5. Other special precautions are similar to those used for flammables (See Section VII A.).

G. SHOCK SENSITIVE/EXPLOSIVE MATERIALS

These are compounds which can spontaneously release large amounts of energy under normal conditions, or when struck, vibrated or otherwise agitated. Some chemicals become increasingly shock sensitive with age. Highly reactive chemicals can lead to reactions that differ from routine controlled reactions mainly in the rate at which they progress. If the heat evolved in a reaction is not dissipated, the reaction rate can increase until an explosion results. The hazard is associated not

with the total energy released, but rather with the high rate of a detonation reaction. A high-order explosion of even milligram quantities can drive small fragments of glass or other matter deep into the body.

Of great concern in the laboratory is the inadvertent formation of explosive or shock sensitive materials such as peroxides, perchlorates (from perchloric acid) and azides. A list of materials which can be shock sensitive is provided below:

ammonium nitrate	hydrazine mixtures	picric acid
calcium nitrate	nitroglycerin	sodium azide
dinitrophenyl hydrazine (2,4-DNP)	nitrotoluene	trinitrotoluene (TNT)
organic peroxides		

Special Precautions for Handling Shock Sensitive or Explosive Materials

1. Contact the Environmental Health and Radiation Safety Department at when work with shock sensitive or explosive materials is being planned or when it is suspected that the inadvertent formation of shock sensitive materials in ductwork, piping or chemicals being stored has occurred.
2. Date all containers of explosive or shock sensitive materials upon receipt and when opened. Unless an inhibitor has been added, unopened shock sensitive materials should be discarded within 12 months after receipt. Open containers should be discarded within 6 months of the date opened.
3. Use the minimum amount of materials necessary for a procedure. Keep a minimum amount of material on hand.
4. Impact-resistant chemical goggles should be worn when handling the material in any way.
5. If there is a chance of explosion, use barriers or other methods for isolating the materials or the process. Gloves should be worn whenever it is necessary to reach behind the shielded area. The yellow "electrical" lineman's gloves afford some protection against 2-g quantity detonations in glass provided the detonation is 7.5cm (3 in.) away; however, such a detonation in contact with a gloved hand would cause severe injury and probable loss of fingers.

H. COMPRESSED GASES

These are materials which are contained under pressure (i.e. dissolved gas or liquified by compression or refrigeration). Compressed gases pose a unique hazard in that they have the potential for simultaneous exposure to both mechanical and chemical hazards. If the gas is flammable, flash points lower than room temperature compounded by high diffusion rates present the danger of fire or explosion. Additional hazards can arise from the reactivity (some, like the anhydrous forms of hydrogen bromide and hydrogen chloride, are corrosive) and toxicity of the gas. Many gases are heavier than air and thus tend to form layers at the lowest level they can reach. Concentrations at floor level or in equipment wells may reach surprisingly high levels. Even inert or nontoxic gases can displace air and collect in concentrations high enough to cause suffocation. Finally, the large amount of potential energy resulting from the compression of the gas makes a compressed gas cylinder a potential rocket or fragmentation bomb.

When considering the toxicity of gases and vapors, the **solubility** of the substance is a key factor. Highly soluble materials like ammonia irritate the upper respiratory tract. On the other hand, relatively insoluble materials like nitrogen dioxide penetrate deep into the lung. Fat soluble materials, like pesticides, tend to have longer residence times in the body.

Research which uses pressurized containers (ACE style or larger reactors/bioreactors) or research which may inadvertently create pressure (LoX accumulation in cold traps) in a container must be tightly controlled via Standard Operating Procedures. Whenever possible, research should be conducted at atmospheric pressure. At a minimum, research which uses pressurized containers should be equipped with a pressure relief device.

Special Precautions for Handling Compressed Gases

1. Always use the smallest size cylinder required to perform the work.
2. Cylinders of compressed gas must be handled as high energy sources.
3. When storing or moving a cylinder, have the cap securely in place to protect the stem. Use suitable racks, straps, chains or stands to support cylinders during use, storage or transportation.

4. Use an appropriate cart to move cylinders.
5. Never bleed a cylinder completely empty. Leave a slight pressure to keep contaminants out.
6. Oil or gas on the high pressure side of an oxygen cylinder can cause an explosion. Do not lubricate an oxygen regulator or a fuel gas regulator on an oxygen cylinder.
7. Always wear safety glasses with side shields or goggles when handling compressed gases.
8. Always use appropriate gauges, fittings and materials compatible with the particular gas being handled.
9. When work with toxic, corrosive or reactive gases is planned, the Environmental Health and Radiation Safety Department should be contacted for information concerning specific handling requirements for the gas involved. Generally, these gases will need to be used and stored with local exhaust ventilation such as a lab hood or a gas cabinet designed for that purpose.

Compressed Gas Cylinder Regulators

Use regulators designed for a specific gas. For proper regulator use Compressed Gas Association (CGA) number (on nut) with corresponding compressed gas cylinder. **DO NOT USE ANY ADAPTER BETWEEN CYLINDERS AND REGULATORS.**

Regulator gauges or hoses should not be interchanged between fuel gas, oxidizing gas, or inert gas.

Before connecting a regulator, crack cylinder valve momentarily to clear valve of dust and dirt. **DO NOT OPEN VALVE NEAR A SOURCE OF IGNITION.**

Use an **AUTOMATIC PRESSURE REGULATOR** which limits pressure to 15 psig maximum with acetylene gas cylinders. *Acetylene can explode if ignited.*

NOTE: Acetylene can also form explosive compounds in contact with copper or brass.

Valves should be closed when not in use, with no pressure on valve or gas lines.

Thaw frozen or ice-clogged valves with warm air or warm water (dry before using). *Do not use boiling water or flame.*

Valve caps must be replaced on empty cylinders during transport and storage.

Valves on corrosive gases should be *inspected frequently*. If corrosion appears, cap cylinder and return to Receiving immediately.

Compressed Gas Storage

Before storing any compressed gas cylinder, the following guidelines should be reviewed and used:

- Large numbers of cylinders shall not be stored in a laboratory.
- Storage area should be set up to ensure *first in, first out usage*.
- Storage area temperature *should not exceed 100°F*.
- Post signs in storage area indicating:
 - Individual gases stocked.
 - Hazards associated with these gases.
- Store gases according to chemical compatibility.
- Store oxidizing gases at least 25 feet from fuel, gases, or any highly combustible materials (i.e. oxygen and hydrogen must be separated from each other).
- Storage areas shall have adequate ventilation. Do not store cylinders in basements or pits unless there is adequate ventilation.
- Protect cylinders from weather extremes, dampness, and direct sunlight.
- Never store cylinder next to radiators or perimeter hot pipes.
- All cylinders shall be secured in an upright position.
- Cylinders of non-liquefied gases should always have a positive pressure of 25 psi or greater to help prevent draw-back and contamination.
- Cylinders should be clearly marked "EMPTY or MT," at the time they are depleted.
- Test all gas joints for possible leaks by applying a soap solution on joint connections. If bubbles form in joint area, this indicates a leak. **IF A LEAK IS FOUND, CONTACT UNIVERSITY OF TOLEDO POLICE DEPARTMENT AT 419-530-2600.**
- To prevent corrosion of regulators, valves and fittings which contact corrosive gases, flush with nitrogen or dry air after use.

I. LIGHT SENSITIVE MATERIALS

Materials which react in the presence of light, forming new compounds which are termed be hazardous, or resulting in hazardous conditions such as pressure build-up inside a container. Examples of light sensitive materials include hydrogen, hydrogen peroxide and chlorine, which can react explosively.

Special Precautions for Handling Light Sensitive Materials

1. Store in a cool dark place in amber colored bottles or other containers which reduce or eliminate penetration of light.
2. Date on receipt and upon opening; dispose of after one year if unopened or 6 months if opened.

J. CRYOGENS

These are materials which have extremely low temperatures. They condense oxygen from the air, creating an oxygen rich atmosphere, increasing potential for fire if flammable or combustible materials and a source of ignition are present. Some of the other hazards associated with cryogenics are pressure, embrittlement of materials and skin or eye burns. Pressure is a hazard because of the large expansion ratio from liquid to gas, causing pressure build-up in containers. Many materials become brittle at extremely low temperatures. Brief bodily contact with materials at extreme low temperatures can cause severe burns. Some examples of cryogenics include liquid nitrogen, liquid hydrogen and solid carbon dioxide (dry ice).

Special Precautions for Handling Cryogens

1. Equipment should be kept clean, especially when working with liquid or gaseous oxygen.
2. Mixtures of gases or fluids should be strictly controlled to prevent formation of flammable or explosive mixtures.
3. For flammable cryogens follow the precautions provided in the Flammable/Combustible Materials (Section VII A.).
4. Always wear safety glasses with side shield or goggles when handling cryogens. If there is a splash or spray hazard, a impervious apron or coat, cuffless pants and high topped shoes should be worn. Watches, rings and other jewelry should not be worn. Gloves should be impervious and sufficiently large to be readily thrown off should a cryogen be spilled. Respirators may be required if the cryogen is toxic and sufficient local exhaust ventilation is not available.

SECTION VIII - CARCINOGENS

Carcinogens are substances that can cause cancer. Harmful health effects of chemicals can range from gross destruction of tissue to interference with normal body functioning to disruption of process within body cells that affect their ability to divide. In cancer, modified body cells start reproducing and continue to do so out of control. This leads to tumor formation and is a severe assault on the body's normal function.

Cancer is not a single disease. Many types of body cells can show cancerous activity and result in different symptoms. The problem of cancer initiation is extremely complex. Not only are the causes uncertain and possibly a combination of factors, including individual susceptibility, but the effects are not immediate. Some cancers may become active after twenty years, making it very difficult to trace back from the effect to the cause. Further complications arise because of the existence of promoters, substances which are not themselves carcinogenic but which can ultimately allow other substances to have a carcinogenic effect. The causes of cancer are not definitely known, although many of them are thought to be dietary or environmental. It has long been known that exposure to some substances is correlated with the development of cancer. With regard to dose levels and the duration of exposure, the range of effects seems to be broad. Some authorities hold that there is no safe exposure level: this conservative view is certainly the safest one.

Substances or groups of substances, including medicines that are **known to be** carcinogenic.^a

- 4-Aminobiphenyl
- Analgesic Mixtures Containing Phenacetin
- Arsenic and Certain Arsenic Compounds
- Asbestos
- Azathioprine
- Benzene
- Benzidine
- Bis(chloromethyl)ether and Technical Grade Chloromethyl Methyl Ether
- 1,4-Butanediol Dimethylsulfonate (Myleran)
- Chlorambucil
- Chromium and Certain Chromium Compounds
- Conjugated Estrogens
- Cyclophosphamide
- Diethylstilbestrol
- Melphalan
- Methoxsalen with Ultra-violet A Therapy (PUVA)
- Mustard Gas
- 2-Naphthylamine
- Thorium Dioxide
- Vinyl Chloride

^a "Known carcinogens" are defined as those substances for which the evidence from human studies indicates that there is a causal relationship between exposure to the substance and human cancer.

Substances or groups of substances, including medicines which may **reasonably be anticipated** to be carcinogens.^a

2-Acetylaminofluorene	Estrogens (Not Conjugated): Estrone
Acrylonitrile	Estrogens (Not Conjugated): Ethinylestradiol
Adriamycin	Estrogens (Not Conjugated): Mestranol
Aflatoxins	Ethyl Acrylate
2-Aminoanthraquinone	Ethylene Oxide
o-Aminoazotoluene	Ethylene Thiourea
1-Amino-2-methylantraquinone	Formaldehyde (Gas)
Amitrole	Hexachlorobenzene
o-Anisidine Hydrochloride	Hexamethylphosphoramide
Benzotrichloride	Hydrazine and Hydrazine Sulfate
Beryllium and Certain Beryllium Compounds	Hydrazobenzene
Bischloroethyl Nitrosourea	Iron Dextran Complex
1,3-Butadiene	Ketone (Chlordecone)
Cadmium and Certain Cadmium Compounds	Lead Acetate and Lead Phosphate
Carbon Tetrachloride	Lindane and Other Hexachlorocyclohexane Isomers
Chlorendic Acid	2-Methylaziridine (Propyleneimine)
Chlorinated Paraffins (C ₁₂ , 60% Chlorine)	4,4'-Methylenebis(2-chloroaniline) (MBOCA)
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)	4,4'-Methylenebis(N,N-dimethyl)benzenamine
Chloroform	4,4'-Methylenedianiline and its Dihydrochloride
3-Chloro-2-methylpropene	Metronidazole
4-Chloro-o-phenylenediamine	Michler's Ketone
C.I. Basic Red 9 Monohydrochloride	Mirex
p-Cresidine	Nickel and Certain Nickel Compounds
Cupferron	Nitrioltriacetic Acid
Dacarbazine	5-Nitro-o-anisidine
DDT	Nitrofen
2,4-Diaminoanisole Sulfate	Nitrogen Mustard Hydrochloride
2,4-Diaminotoluene	2-Nitropropane
1,2-Dibromo-3-chloropropane	N-Nitrosodi-n-butylamine
1,2-Dibromoethane (EDB)	N-Nitrosodiethanolamine
1,4-Dichlorobenzene	N-Nitrosodiethylamine
3,3'-Dichlorobenzidine and 3,3'-dichlorobenzidine Dihydrochloride	N-Nitrosodimethylamine
1,2-Dichloroethane	p-Nitrosodiphenylamine
Dichloromethane (Methylene Chloride)	N-Nitrosodi-n-propylamine
1,3-Dichloropropene (Technical Grade)	N-Nitroso-N-ethylurea
Diepoxybutane	N-Nitroso-N-methylurea
Di(2-ethylhexyl)phthalate	N-Nitrosomethylvinylamine
Diethyl Sulfate	N-Nitrosomorpholine
Diglycidyl Resorcinol Ether	N-Nitrososarcosine
3,3'-Dimethoxybenzidine	N-Nitrosopiperidine
4-Dimethylaminoazobenzene	N-Nitrosopyrrolidine
3,3-Dimethylbenzidine	N-Nitrososarcosine
Dimethylcarbamoyl Chloride	Norethisterone
1,1-Dimethylhydrazine	4,4'-Oxydianiline
Dimethyl Sulfate	Oxymetholone
Dimethylvinyl Chloride	Phenacetin
1,4-Dioxane	Phenazopyridine Hydrochloride
Direct Black 38	Phenoxybenzamine Hydrochloride
Direct Blue 6	Phenytoin
Epichlorohydrin	Polybrominated Biphenyls
Estrogens (Not conjugated): Estradiol-17	Polychlorinated Biphenyls
	Polycyclic Aromatic Hydrocarbons, 15 listings

Substances or groups of substances, including medicines which may **reasonably be anticipated** to be carcinogens (continued).^a

Benz(a)anthracene	Propylthiouracil
Benzo(b)fluoranthene	Reserpine
Benzo(j)fluoranthene	Saccharin
Benzo(k)fluoranthene	Safrole
Benzo(a)pyrene	Selenium sulfide
Dibenz(a,h)acridine	Streptozotocin
Dibenz(a,h)anthracene	Sulfallate
7H-Dibenzo(c,g)carbazole	2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)
Dibenzo(a,e)pyrene	Tetrachloroethylene (Perchloroethylene)
Dibenzo(a,h)pyrene	Thioacetamide
Dibenzo(a,i)pyrene	Thiourea
Dibenzo(a,l)pyrene	Toluene Diisocyanate
Indeno(1,2,3-cd)pyrene	o-Toluidine and o-Toluidine Hydrochloride
5-Methylchrysene	Toxaphene
Procarbazine Hydrochloride	2,4,6-Trichlorophenol
Progesterone	Tris(1-aziridinyl)phosphine Sulfide
1,3-Propane Sultone	Tris(2,3-dibromopropyl)phosphate
b-Propiolactone	Urethane
Propylene Oxide	

^a Substances "which may reasonable be anticipated to be carcinogens" are defined as those for which there is a limited evidence of carcinogenicity in humans or sufficient evidence of carcinogenicity in experimental animals.

It is important to keep the problem of carcinogens in the proper perspective. Millions of chemicals are known. Of these, perhaps 40,000-100,000 find some use in commerce and the chemical industry. Yet OSHA only specifically regulates 12 known carcinogens and 40 suspect carcinogens.

For the most up to date listing of carcinogens consult the following resources available from the Environmental Health and Radiation Safety Department:

- National Toxicology Program (NTP)
- International Agency for Research on Cancer (IARC)
- American Congress of Governmental Industrial Hygienists (ACGIH)
- Occupational Safety and Health Administration (OSHA)

SECTION IX - RADIOACTIVE MATERIALS

The use of radioactive materials is permitted only under the conditions of UT's Nuclear Regulatory Commission license or by the Ohio Department of Health/Bureau of Radiological Health.

All use of radioactive materials must have prior approval by the UT Radiation Safety and Radioisotope Committee. This is done by application to the committee which meets once each quarter. Applications can be obtained through the Radiation Safety Office at (419) 383-4301.

Approved Users are only permitted to order radioactive materials in the types and quantities listed on their Certificate of Use issued by the Radiation Safety and Radioisotope Committee. Verification by the Radiation Safety Office is required prior to ordering. Any request for radioactive materials not stamped by Radiation Safety will be returned resulting in delays of the request.

Any person using radioactive materials must be trained in the safe handling of radioactive materials prior to use. General training is offered by the Radiation Safety Office. This training is required and must be taken within the first six months of working in a radioisotope lab. Training by the Approved User in their specific protocols is required before any handling of radioactive materials. All use by an untrained person must be directly supervised until all training is completed.

Radiation safety procedures are found in the Radiation Safety Manual. If you have any questions regarding policies or procedures contact the Radiation Safety Office at ext. (419) 383-4301.

SECTION X - BIOHAZARDS

Items included in this category are blood and blood products, any body fluid, contaminated sharps (i.e. needles, scalpels), pathological wastes, microbiological wastes, and blood and organs or other tissues infected or potentially infected with human immunodeficiency virus (HIV), hepatitis B virus (HBV) or other infectious agent. Biosafety in laboratories is covered in detail in the publication by CDC-NIH, Biosafety in Microbiological Laboratories (BMBL Most Current Edition)[HHS Publication Number (NIH) 88-8395]. Consult the University of Toledo's Institutional Biosafety Manual for more information.

Special Precautions for Handling Potentially Infectious Material

1. **All** blood and body fluids should be considered potentially infectious.
2. **All** leaking specimen containers must be handled with gloved hands.
3. Laboratory coats, gowns or uniforms must be worn while working with potentially infectious materials and should be removed before leaving the area. Hands should be washed after removing protective clothing and before leaving the area.
4. Gloves must be worn when handling blood, tissue, body fluids, excretions and secretions. Hands must also be gloved when coming in contact with contaminated surfaces, materials or blood-soaked items. Masks and protective eye wear should be worn if mucous membrane contact with blood or body fluids is possible. Gloves should be changed and hands washed after completion of specimen processing.
5. Biological safety cabinets (Class II) and other primary containment devices (i.e. centrifuge safety cups) are advised whenever procedures are conducted that have a high potential for creating aerosols or droplets. These procedures should be performed carefully to minimize the creation of droplets or aerosols. Primary containment devices should also be used in handling materials that might also contain concentrated infectious agents or organisms in greater quantities than expected in clinical specimens.
6. Pipetting devices must be used for the manipulation of all liquids. DO NOT mouth pipette.
7. Tissue or serum specimens for long term storage should be clearly and permanently labeled as potentially biohazardous.
8. Work surfaces should be decontaminated with a fresh 1:10 solution of bleach to water or other appropriate disinfectant at the end of each shift and following any spillage of potentially infectious material.
9. Infectious waste should be processed according to established policy. Any sharp object (needles, skin lances, scalpel blades) should be placed in a puncture resistant, tamper-proof container labeled as biohazardous. Needle shearing devices are not approved for use at the University of Toledo.
10. Liquid infectious waste, such as blood may be disposed of in the sanitary sewer. Proper personal protection equipment should be used during this process to protect the person from splashes. As always, contact the Environmental Health and Radiation Safety Department if you have any questions. See the University of Toledo's Exposure Control Plan found at http://www.utoledo.edu/policies/utmc/infection_control/pdfs/1%20Bloodborne%20Pathogens%20Exposure%20Control%20Plan%20%202011.pdf.
11. Equipment that has been contaminated with blood or body fluids shall be thoroughly decontaminated and cleaned before leaving the laboratory.
12. Take extraordinary care to avoid accidental injuries caused by needles, scalpel blades and laboratory instruments when performing procedures, cleaning instruments, handling sharp instruments and disposing of used needles.
13. Specimens which are being moved (i.e. between buildings) or are intended for transportation should be placed into a sealed leak-proof primary container. This in turn should be placed in secondary container, such as a plastic bag with a grip lock or metal twist tie closure.
14. Consult UT policies HM-08-019 Infectious Waste Disposal and HM-08-020 Disposal of Sharps policy for further information regarding the handling and disposal of Infectious Materials.

Special Precautions for Animal Handling

Precautions for use of animals in animal research involving hazardous agents are described in the Guide for the Care and Use of Laboratory Animals, NIH Publication No. 86-23, available from the U.S. D.H.H.S. (Contact DLAR for a copy.)

SECTION XI - ASBESTOS

Asbestos was the material of choice for many years when architects and engineers were planning construction requiring insulation, sound-proofing, strength or fire resistance. That started to change in the 1970's when evidence indicating the hazards of its use began to outweigh its value. Currently, there are few products or applications where asbestos has not been replaced by safer materials.

Regulations have been established to deal with the exposure to and disposal of asbestos. The Environmental Protection Agency (EPA) regulations focus on the application and removal of asbestos containing material (ACM) in new or remodeled buildings, identification of asbestos in building materials, industrial emission of asbestos fibers and the disposal of asbestos waste. The Occupational Safety and Health Administration (OSHA) addresses employee protection in the workplace. Current regulations restrict the use of most asbestos products in new buildings and specifies work practices for removal of ACM from buildings.

Although ACM is present in most pre-1980 construction, a section from the EPA publication *Guidance for Controlling Asbestos-Containing Materials in Buildings* helps put the risks in perspective.

Construction materials containing asbestos have been used extensively in schools and other buildings. The concern about exposure to asbestos in these buildings is based on evidence linking various respiratory diseases with occupational exposure in the shipbuilding, mining, milling and fabricating industries. The presence of asbestos in a building does not mean that the health of building occupants is endangered as long as ACM remains in good condition and is unlikely to be disturbed by maintenance and repairs are conducted with proper controls.

Inhalation is the primary route of entry for asbestos into the body; this may lead to respiratory disease. All known disease associated with ACM exposure take many years (up to 30) from the time of initial exposure to appear as symptoms. History also shows that, like most toxic substances, incidence and severity of symptoms are related to the frequency and concentration of exposure to asbestos fibers.

At UT, asbestos abatement projects are undertaken primarily for two reasons: building renovation or utility repairs or access. According to EPA protocol, the area surrounding ACM to be removed is isolated with a double layer of polyethylene. This enclosure contains fibers that are released during the removal process. Negative air pressure is maintained within the enclosure to ensure that asbestos fibers are not released into the surrounding area. Air within the enclosure is filtered by the use of High Efficiency Particulate (HEPA) filters which remove asbestos fibers from the air. Abatement workers wear respirators and disposable suits to protect themselves. Air samples are taken on the abatement workers and outside the containment area to insure safe conditions for the abatement crew and integrity of the surrounding area. At the conclusion of the abatement projects, all materials are double bagged and transported to an approved landfill.

Asbestos management and abatement at UT is the responsibility of the Environmental Health and Radiation Safety Department and Facilities Maintenance Departments jointly. Remember that asbestos is not a hazard until fibers are released from contaminated materials. If you suspect that a material contains asbestos, leave the material undisturbed and contact your supervisor. Supervisors should contact the Environmental Health and Radiation Safety Department with any concerns regarding asbestos.

In the laboratory setting fume hoods are many times lined with a form of asbestos that is rigid and gray in color. No attempt should be made to modify the internal portions of chemical fume hoods.

SECTION XII - SOLVENTS

No single chemical class can be defined as a solvent, but it is natural to consider solvents as a group because of their common characteristics in handling, use and storage.

Many solvents are flammable liquids, thus presenting more of a safety hazard than a health hazard (see Flammable/Combustible Section VII A for details). However, there can also be health effects of many kinds: solvents may also be toxic, corrosive or irritants.

Skin exposure should be avoided as a matter of common sense. Solvents can remove protective oils from the skin; some even penetrate the skin. Many solvents can cause systemic or target-organ damage, particularly to the liver and blood-forming organs.

Solvents should be used with adequate ventilation. Almost all organic solvents, if inhaled, will have an anesthetic effect, leading to dizziness, drowsiness or unconsciousness. Prolonged exposure, which can occur if an unconscious person remains in an atmosphere contaminated with solvent fumes, could lead to death.

Some common toxic solvents are:

aniline	dinitrobenzenes	nitrobenzene
carbon tetrachloride	epichlorohydrin	tetrachloroethylene
chloroform	methanol	toluidine

Some common corrosive solvents are:

acetic anhydride	benzoyl chloride	ethanolamine
acetic acid, 50% to 80%	benzyl bromide	1-pentol
acetic acid, glacial	diethylenetriamine	tributylamine

SECTION XIII - SAFETY DATA SHEETS AND OTHER REFERENCE

Global Harmonization System (GHS)

The Occupational Safety and Health Administration's (OSHA) Hazard Communication Standard has aligned with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

The standard provides a single set of harmonized criteria for classifying chemicals according to their health and physical hazards and specifies hazard communication elements for labeling and safety data sheets.

General

A Safety Data Sheet (SDS) is a document containing chemical hazard information and is prepared in accordance with the OSHA Hazard Communication Standard. Other reference material which describes the safe handling, storage and disposal of hazardous chemicals may be used.

When SDS's are received in the laboratory they are to be retained in/placed in your lab's safety manual or in a dedicated book. Ensure you have an SDS for all "Hazardous Chemicals" as definition in Section V.

It is preferred that Lab personnel create a folder in Chemwatch for their lab to keep SDS's on file electronically.

Principal Investigators are responsible to ensure that an updated chemical inventory and SDS's are available for laboratory workers.

Guidelines for Reading and Understanding an SDS Section by Section

SDS's now require a 16 section format (see 1910.1200 Appendix D). The following section numbers and headings must be included, in order:

- Section 1 – Identification
- Section 2 – Hazard(s) identification
- Section 3 – Composition/information on ingredients
- Section 4 – First-aid measures
- Section 5 – Fire-fighting measures
- Section 6 – Accidental release measures
- Section 7 – Handling and storage
- Section 8 – Exposure controls/personal protection
- Section 9 – Physical and chemical properties
- Section 10 – Stability and Reactivity
- Section 11 – Toxicological Information
- Section 12 – Ecological Information
- Section 13 – Disposal Considerations
- Section 14 – Transport Information
- Section 15 – Regulatory Information
- Section 16 – Other information including date of preparation or last revision

SECTION XIV - LABELING

Labeling is an important means of communicating container contents and potential hazards associated with chemicals. Furthermore, it is important to use a coding or labeling system which communicates such hazards to the people who come in contact with chemicals.

Under no circumstances should unlabeled chemicals or waste materials exist in a laboratory setting.

Global Harmonization System (GHS) Labeling System

Under the GHS system, labels on shipped containers must contain the following:

Product identifier

Signal word

Hazard statement(s);

Pictogram(s);


Precautionary statement(s); and,

Name, address, and telephone number of the chemical manufacturer, importer, or other responsible party.

All chemicals in the lab must be labeled with the original shipping label or the following:

Product identifier and words, pictures, symbols, or combination thereof, which provide at least general information regarding the hazards of the chemicals, and which, in conjunction with the other information immediately available to employees under the hazard communication program, will provide employees with the specific information regarding the physical and health hazards of the hazardous chemical. Labels for secondary containers can be printed on Chemwatch.

HCS Pictograms and Hazards

<p>Health Hazard</p>  <ul style="list-style-type: none"> ▪ Carcinogen ▪ Mutagenicity ▪ Reproductive Toxicity ▪ Respiratory Sensitizer ▪ Target Organ Toxicity ▪ Aspiration Toxicity 	<p>Flame</p>  <ul style="list-style-type: none"> ▪ Flammables ▪ Pyrophorics ▪ Self-Heating ▪ Emits Flammable Gas ▪ Self-Reactives ▪ Organic Peroxides 	<p>Exclamation Mark</p>  <ul style="list-style-type: none"> ▪ Irritant (skin and eye) ▪ Skin Sensitizer ▪ Acute Toxicity ▪ Narcotic Effects ▪ Respiratory Tract Irritant ▪ Hazardous to Ozone Layer (Non-Mandatory)
<p>Gas Cylinder</p>  <ul style="list-style-type: none"> ▪ Gases Under Pressure 	<p>Corrosion</p>  <ul style="list-style-type: none"> ▪ Skin Corrosion/Burns ▪ Eye Damage ▪ Corrosive to Metals 	<p>Exploding Bomb</p>  <ul style="list-style-type: none"> ▪ Explosives ▪ Self-Reactives ▪ Organic Peroxides
<p>Flame Over Circle</p>  <ul style="list-style-type: none"> ▪ Oxidizers 	<p>Environment (Non-Mandatory)</p>  <ul style="list-style-type: none"> ▪ Aquatic Toxicity 	<p>Skull and Crossbones</p>  <ul style="list-style-type: none"> ▪ Acute Toxicity (fatal or toxic)

SECTION XV - INDUSTRIAL TOXICOLOGY

Toxicology is the study of the nature and action of poisons.

Toxicity is the ability of a substance to produce injury once it reaches a susceptible site in the body.

Toxicity hazard is the probability that a toxic concentration (dose) in the body will occur. Many factors contribute to the degree of hazard, i.e. route of entry, physiological state and environmental factors.

A. DOSE-RESPONSE RELATIONSHIPS

There is a correlation between the amount of exposure to an agent and the resulting effect on the body. The most toxic chemical known, if present in small enough amounts - a few molecules - will produce no measurable effect. It may damage one cell or several cells, but no effect, such as kidney dysfunction, will be measured. As the dose is increased, there is a point when the first measurable effect is noted. The toxic potency of a chemical is defined by the relationship between the dose (the amount) of the chemical and the response that is produced in a biological system. Thus, a high concentration of toxic substance in the target organ will cause a severe reaction, and a low concentration, a less severe reaction.

B. ROUTES OF ENTRY INTO THE BODY

- There are four main routes by which hazardous chemicals enter the body:
- Absorption through the respiratory tract by **inhalation**. Most important in terms of severity.
- Absorption through the **skin**, mucous membranes, and eyes.
- Absorption through the digestive tract by **ingestion**. Can occur through eating or smoking with contaminated hand or in contaminated work areas.
- **Injection**: Can occur through accidental needle stick or puncture of skin with sharp object.

Most exposure standards, Threshold Limit Values (TLV's) and Permissible Exposure Limits (PELs), are based on the inhalation route of exposure. They are normally expressed in terms of part per million (ppm) or milligrams per cubic meter (mg/m^3) concentration in air.

If a significant route of exposure is through skin contact, the TLV or PEL will have a "skin" notation. Examples are pesticides, carbon disulfide, carbon tetrachloride, dioxane, mercury, thallium compounds, xylene and hydrogen cyanide.

C. TYPES OF TOXICITY

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

Chronic effects are characterized by prolonged or repeated exposures of a duration measured in weeks, months or years. Symptoms may not be immediately apparent. Examples are lead or mercury poisoning and pesticide exposure.

Local effects refer to the site of action of the agent and are a result of direct contact of the irritant with tissue. Often this refers to the skin, mucous membranes, eyes or throat. Absorption does not necessarily occur and toxic effect due to the exposure to usually not seen elsewhere. Examples are strong acids or alkalis and war gases.

Systemic effects refer to a site of action other than the point of contact. A material cannot produce a systemic injury unless it gains entry into the blood stream via ingestion, inhalation or absorption. For example an inhaled material may act on the liver. Examples: arsenic affects the blood, nervous system, liver, kidneys and skin; benzene affects bone marrow.

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

Combined Effects of Materials

Addition - the toxic action of the two materials is the summed effect of each given alone (i.e. $2 + 3 = 5$). Example: carbon monoxide and methylene chloride both increase the formation of carboxyhemoglobin and the amounts formed by each are strictly additive.

Synergism - the existence of one material increases the toxic action of the other (i.e. $2 + 3 = 10$). Example: both carbon tetrachloride (CCl_4), and ethanol are hepatotoxins, but together they produce more liver injury than they would alone.

Potentiation - the presence of a nontoxic material (the potentiator) increases the toxic action of the other (i.e. $0+3=10$). Example: isopropanol is not hepatotoxic, but when added to CCl_4 , the hepatotoxicity of CCl_4 is much greater than when it acts alone.

Antagonism - the existence of one material reduces and interferes with the toxic action of the other. Example: antidotes, activated charcoal, drugs with blocking action or drugs with opposite effects.

D. OTHER FACTORS AFFECTING TOXICITY

Rate of entry and route of exposure; that is, how fast is the toxic dose delivered and by what means.

Age can affect the capacity to repair damage.

Previous exposure can lead to tolerance, increased sensitivity or make no difference.

State of health, medications, physical condition and life style can affect the toxic response. Pre-existing disease can result in increased sensitivity.

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

E. PHYSICAL CLASSIFICATIONS OF TOXIC MATERIALS

Gas: a form of matter that is neither solid nor liquid. In its normal state at room temperature and pressure, it can expand indefinitely to completely fill a container. A gas can be changed to its liquid or solid state under the right temperature and pressure conditions.

Vapor: the gaseous phase of a material which is ordinarily a solid or a liquid at room temperature and pressure. Vapors also diffuse. Evaporation is the process by which a liquid is changed into the vapor state and mixed with the surrounding air. Solvents with low boiling points will volatilize readily.

Aerosol: liquid droplets or solid particles dispersed in air that are of fine enough size (less than 100 micrometers) to remain dispersed for a period of time. The toxic potential of an aerosol is only partially described by its concentration in mg/m^3 . For a proper assessment of the toxic hazard, the size of the aerosol's particles is important. Particles between 5 and 10 micrometers (μm) will only deposit in the upper respiratory tract. Those between 1 and $5\mu\text{m}$ will deposit in the lower respiratory tract. Very small particles ($<0.5\mu\text{m}$) are generally not deposited.

Dust: solid particles suspended in air produced by some physical process such as crushing, grinding, abrading or blasting. Dusts may be an inhalation, fire or dust-explosion hazard.

Mist: liquid droplets suspended in air produced by some physical process such as spraying, splashing, boiling or by condensation of vapor.

Fume: an airborne dispersion of minute solid particles arising from the heating of a solid (such as molten metal). Gases and vapors are not fumes, although the terms are often mistakenly used interchangeably.

Smoke: minute airborne particles either liquid or solid (but usually carbon or soot), generated as a result of incomplete combustion of an organic material.

F. GENOTOXIC EFFECTS

Carcinogens are substances that induce a malignant growth in a cell, tissue or organ following exposure.

Mutagens are substances capable of causing heritable changes in the genetic information stored in the DNA of living cells.

Teratogens (embryotoxic or fetotoxic agents) are substances that affect the fetus through the mother so that the fetus is either killed in utero or is born with physical, mental, behavioral or developmental defects.

G. TARGET ORGAN EFFECTS

The following is a target organ categorization of effects which may occur, including examples of signs and symptoms and chemicals which have been found to cause such effects. These examples are presented to illustrate the range and diversity of effects and hazards found in the workplace, and the broad scope employers must consider in this area, but are not intended to be all-inclusive.

Hepatotoxins: chemicals which produce liver damage

Signs & Symptoms: jaundice, liver enlargement
Chemicals carbon tetrachloride, nitrosamines

Nephrotoxins: chemicals which produce kidney damage

Signs & Symptoms: edema, proteinuria
Chemicals halogenated hydrocarbons, uranium

Neurotoxins: chemicals which produce their primary toxic effects on the nervous system

Signs & Symptoms: narcosis, behavioral changes, decrease in motor or sensory functions
Chemicals mercury, carbon disulfide, organophosphorus-containing compounds (insecticides)

Agents which damage the lung: chemicals which irritate or damage the pulmonary tissue

Signs & Symptoms: cough, tightness in chest, shortness of breath
Chemicals silica, asbestos

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

Signs & Symptoms: birth defects, sterility
Chemicals lead, dibromochloropropane (DBCP)

Cutaneous hazards: chemicals which affect the dermal layer of the body

Signs & Symptoms: defatting of skin, rashes, irritation
Chemicals ketones, chlorinated compounds (insecticides), also variety of solvents

Eye hazards: chemicals which affect the eye or visual capacity

Signs & Symptoms: conjunctivitis, corneal damage
Chemicals organic solvents, acids

H. OTHER EFFECTS

Irritants are materials that cause inflammation of mucous membranes with which they come in contact. Long term exposure to irritants can result in increased mucous secretions and chronic bronchitis. Inflammation of tissue results from concentrations far below those needed to cause corrosion. Examples include:

ammonia	alkaline dust and mists	arsenic trichloride
diethyl/dimethyl sulfate	halogens	hydrogen chloride
hydrogen fluoride	nitrogen dioxide	ozone
phosgene	phosphorus chlorides	

Irritants can also cause changes in the mechanics of respiration and lung function. Examples include:

acetic acid	acrolein	formic acid
formaldehyde	iodine	sulfur dioxide
sulfuric acid		

A **primary irritant** exerts no systemic toxic action either because the products formed on the tissue of the respiratory tract are non-toxic or because the irritant action is far in excess of any systemic toxic action. An example is hydrogen chloride.

A **secondary irritant's** effect on mucous membranes is over-shadowed by a systemic effect resulting from absorption. Exposure to these can result in pulmonary edema, hemorrhage and tissue death. Examples include hydrogen sulfide and aromatic hydrocarbons.

Corrosives are chemicals which may cause visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact. See the Corrosives Section VII B for further details.

Asphyxiants have the ability to deprive tissue of oxygen.

Simple asphyxiants replace air with something else, usually inert gases. Examples include:

carbon dioxide	helium	hydrogen
methane	nitrogen	nitrous oxide

Chemical asphyxiants reduce the oxygen carrying capacity of the blood. They are active at very low concentrations. Examples include:

carbon monoxide	cyanides	hydrogen sulfide
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Sensitizers cause a major proportion of exposed people to develop an allergic reaction in normal tissue after repeated exposure to a chemical. The reaction may be as a rash (contact dermatitis) or as serious as anaphylactic shock. Examples include:

epoxides	formaldehyde	naphthalene
nickel compounds	nitrobenzene	penicillin
poison ivy	toluene diisocyanate	

Anesthetics have a depressant effect upon the central nervous system, particularly the brain. Examples include:

halogenated hydrocarbons	chlorinated solvents	alcohols
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I. EXPOSURE MODELING/MEDICAL SURVEILLANCE

Employee environmental/occupational exposure monitoring and medical surveillance shall be conducted and maintained in accordance with applicable codes and standards. Refer to HM-08-016.

<http://www.utoledo.edu/depts/safety/docs/HM-08-016.pdf>

SECTION XVI - ENGINEERING CONTROLS

Exposure to hazardous materials should be controlled to the greatest extent feasible by use of engineering controls. For assistance in determining engineering controls necessary for your work situation, contact the Environmental Health and Radiation Safety Department. Engineering controls to reduce or eliminate exposures to hazardous chemicals include:

- Substitution of less hazardous material, equipment or process (i.e. safety cans for glass bottles)
- Isolation of the operator or the process (i.e. use of barriers when handling explosives, or completely enclosing process in a glove box or other enclosure).
- Local and general exhaust ventilation (i.e. use of fume hoods)

Ventilation Controls. To determine ventilation requirements, check the SDS. Expressions on an SDS such as those listed below indicate a need for ventilation:

- use with adequate ventilation, avoid vapor inhalation
- use in a chemical exhaust hood (fume hood)
- provide local exhaust ventilation

Ventilation recommendations must be adapted to the work site and the specific process. For assistance in determining specific ventilation requirements for your work situation contact the Environmental Health and Radiation Safety Department.

Proper use of ventilation systems

Once a ventilation system is installed in the work area, it must be used properly to be effective. The objective of a local exhaust ventilation system is to draw hazardous materials in the air away from the breathing zone of the employee. **The system must be checked prior to each use to assure it is operating.** If the system is not working, it should be posted out of order and the Facilities Maintenance should be contacted to have the system repaired. **Never work with hazardous materials if the required ventilation system is not functioning properly.**

Ventilation systems must be properly configured. Be sure you know how to properly use the system in your area for the work you are doing. For use of laboratory fume hoods, the following guidelines should be followed:

1. Fume hoods should be marked to indicate proper sash position for optimum hood performance. The hood sash should be set at this point or lower for procedures which may generate toxic aerosols, gases or vapors. If it is not possible to do work with the sash height set at the point marked or lower, or if there is no marking on the hood, contact the Environmental Health and Radiation Safety Department. In general, the sash height should be set at a level where the operator is shielded to some degree from any explosions or violent reactions which may occur and where optimum air flow dynamics are achieved. Fume hoods are not intended to be used with the sash fully opened.
2. All work with hazardous chemicals should be done at least 6 inches inside the front edge of the hood.
3. Fume hoods should be equipped with a manometer or magnehelic gauge to indicate adequacy of flow. Learn how to read and interpret this gauge and check it daily. If the gauge indicates a reduced flow in the hood, post the hood out of order and contact your supervisor to have the hood repaired.
4. Only apparatus and chemicals essential to the specific procedure or process should be present in the hood. Extra materials from previous experiments or procedures should be removed and stored in a safe location outside the hood. Certain exemptions will be granted after consultation with the Environmental Health and Radiation Safety Department for the storage of malodorous chemicals. No experimental work should be conducted in these hoods. Hoods used for experimental work should not be used for chemical or material storage. Radioactive materials and waste should not be stored in your fume hood unless those materials are volatile in nature.
5. DO NOT work with hazardous materials across the room from an exhaust unit. The materials may in turn expose a number of other people present within the laboratory. Work upstream with an unimpeded path to the exhaust unit.

If there are any questions concerning the adequacy of a fume hood or the procedures for safe use of a fume hood, contact the Environmental Health and Radiation Safety Department.

SECTION XVII - ADMINISTRATIVE CONTROLS

Administrative controls are procedural measures which can be taken to reduce or eliminate hazards associated with the use of hazardous materials. They include the following:

- Careful planning of experiments and procedures with safety in mind. This planning should include development of written work procedures for safe performance of the work
- Many times this work will have to be approved by an institutional committee such as the Radioisotope, Biosafety or IACUC
- Restricting access to areas in which hazardous materials are used
- Using signs or placards to identify hazardous areas
- Limiting contact time (e.g. radiation)
- Use of labels on hazardous materials
- Substitutions of less toxic materials for toxic materials
- Good housekeeping
- Good hygiene (i.e. washing hand and other areas of possible chemical contact)
- Prohibiting eating, drinking and smoking, use of other tobacco products, electronic cigarettes in areas of chemical use, and providing break areas for this purpose
- No mouth pipetting
- Use only appropriately labeled container for the disposal of materials within the laboratory.
- Adding acid to water, never water to acid
- Assuring employees are provided adequate training for safe work with hazardous materials
- Working with materials on a microscale.

Restricted access areas

Facilities placarded with following warning signs are restricted access areas:

CAUTION - BIOHAZARDS (Biosafety Level 2 or 3)
CANCER - HAZARD
CAUTION - RADIOACTIVE MATERIAL
CAUTION - X-RAY
CAUTION - LASER

A list with names and phone numbers of responsible personnel should be posted on the door(s) to any facilities where hazardous materials are used or stored.

Students, faculty, staff and administrators shall not enter a restricted area except when accompanied by an authorized user of the facility.

Environmental Services and custodial staff are permitted to enter restricted areas after proper training to perform routine tasks.

Other support personnel, such as University of Toledo Police Department are permitted to enter restricted areas after they have been informed of the hazards in the area. Support personnel should contact an authorized user of the facility or the Environmental Health and Radiation Safety Department before performing maintenance work/repair which may involve any of the following items:

- chemical exhaust hoods (fume hoods)
- biological safety cabinets
- sinks
- placarded equipment
- chemicals or materials on lab benches

Hazard Warning Signs and Postings

Hazard warning signs are used to inform those who might come into contact with a hazard, about that hazard.

Examples of these include:

- Infectious waste storage
- Radiation area
- Laser operations
- Flammable materials
- Biohazardous agents (BSL2 or 3 Containment Labs)
- Potential carcinogen use or storage

Another type of safety sign system helps locate critical safety equipment:

- Safety showers
- Eye wash stations
- Exits
- Fire extinguishers
- SDSs
- Personal protective equipment

Minors in Research Labs with inherently or potentially hazardous chemicals, radioactive materials, biohazards, or hazardous equipment:

In keeping with the institution's mission of education and outreach, The University of Toledo provides opportunities to individuals under the age of 18 years old to gain experience in research laboratories for educational purposes. Environmental, Health and Radiation Safety procedure #HM-08-015 describes the requirements that must be fulfilled before minors participate in different levels of laboratory activities.

SECTION XVIII - PERSONAL PROTECTIVE EQUIPMENT

A. GENERAL CONSIDERATIONS

Personal protective devices may be needed to supplement engineering controls available, but are never to be used as a substitute for engineering controls except as a temporary measure while such controls are being instituted, or for short term jobs where the implementation of engineering controls are not feasible.

The applicable SDS will provide some information on the personal protective equipment (PPE) recommended for use with the chemical. In some cases, the SDS may not provide sufficient information concerning a specific respirator or type of glove appropriate for the chemical. Contact your supervisor for additional information.

Your supervisor, instructor or Environmental Health and Radiation Safety Department will determine which PPE devices are required for each task. Using the wrong PPE for certain tasks can be hazardous to your health.

The PI should complete a PPE hazard assessment and departments must provide required personal protective equipment to employees. A sample PPE hazard assessment can be found at <http://www.utoledo.edu/depts/safety/docs/S-08-032AppendixA.pdf>

B. PROTECTION AGAINST INHALATION HAZARDS

When ventilation is not adequate to provide protection against an inhalation hazard, respiratory protective equipment may be necessary. There are a variety of respirators available for use, but no one device which will provide protection against all possible hazards. It is important to select equipment which is suited to the chemical and the process for which it is to be used. Respirator selection is based on the hazard and the protection factors required.

Types of respiratory protective equipment include:

- particle-removing air-purifying respirators
- gas and vapor-removing air-purifying respirators
- atmosphere-supplying respirators

Respirators are not to be used except in conjunction with a complete respiratory protection program. Such a program includes a review of the process to assure the proper equipment is selected for the job, training of all respiratory protective equipment users concerning the proper methods for use and care of such equipment, fitting of respirator users when required; and medical surveillance of respirator users when required.

If your work requires the use of a respirator or you suspect your work requires the use of a respirator you should contact your supervisor. She must contact the Environmental Health and Radiation Safety Department for an evaluation of the situation and to arrange for fitting of the equipment and training in use and care of the equipment.

Do not use respiratory protective equipment until you have received the proper training and medical surveillance. If you are currently using a respirator and you have not received training in its use and care, contact the Environmental Health and Radiation Safety Department immediately.

In some cases, respirators may be kept on hand for emergencies. In this situation, all potential users must receive training. In addition, the equipment must be inspected on a monthly basis and this inspection must be documented. If you have respiratory protective equipment on hand for use in an emergency and you have not received training in its use and care, contact the Environmental Health and Radiation Safety Department immediately.

For more information on the UT Respiratory Protection Program refer to [S-08-034](#).

PROTECTION OF SKIN AND BODY

Skin and body protection involves protective clothing and include protection of the various parts of the body either completely or partially.

- Do not wear open-toed shoes, sandals, shorts, etc. in chemical laboratories.
- Cover all unprotected skin surfaces.
- Where there is no immediate danger to the skin from contact with a hazardous chemical, but where street clothes are vulnerable to damage, lab coats, coveralls, aprons or protective suits shall be used.

Eye and face injuries are prevented by use of the following:

- safety glasses with side shields for dust and flying objects protection.
- splash-proof goggles for chemical splash, spray and mist protection, vented or unvented dependent on vapors.
- full-face and neck shields for head and neck protection from various hazards (must be used with safety glasses or goggles)
- Do not wear contact lenses without goggles in chemical-use areas.
- Splash-proof goggles provide superior protection against dust, flying objects, and splash, spray and mist hazards. They should be the first choice for primary eye protection.

General categories of contaminants include:

- dirt and grease
- bacteriological agents
- toxic dust
- radioactive materials
- lab chemicals

These garments should not leave the work site. For heavily contaminated work, special attention must be given to sealing all openings in the clothing. Tape can be utilized for this purpose. Caps should be worn to protect hair from contamination.

Exposures to strong acids and acid gases, organic chemicals and strong oxidizing agents, carcinogens and mutagens require the use of protective equipment that prevent skin contamination. Impervious protective equipment must be used. Examples include:

- chemical-resistant gloves
- chemical-resistant boots
- chemical-resistant suits
- special protective equipment

Protective garments are not equally effective for every hazardous material. Some chemicals will "break through" the garment in a very short time. Therefore, garment selection is based on the specific chemical used. Determine the chemicals to be used, then refer the manufacturer's information or contact your supervisor, instructor or the Environmental Health and Radiation Safety Department for specific recommended clothing. Several guides are available on-line through Kimberly Clark and Ansell.

Fluid proof gowns may be required when there is a potential for a splash or exposure to blood or other potentially infectious materials. Fluid proof gowns should be of the disposable type and discarded when soiled.

SECTION XIX - CHEMICAL STORAGE

Fume hoods are not considered chemical storage areas in most situations.

Carefully read the label before storing a hazardous chemical. The SDS should provide any special storage information and incompatibilities.

Assure all containers are in good condition and **properly labeled**.

Do not store unsegregated chemicals in alphabetical order. Once separated into hazard classes, chemicals may be stored alphabetically.

Do not store incompatible chemicals in close proximity to each other. See the tables below for some specific examples.

Separate hazardous chemicals in storage as follows:

solids	oxidizers flammable solids water-reactives
liquids	mineral acids oxidizers acids bases perchloric acid flammable/combustibles (includes organic acids)
gases	toxic flammable oxidizers and inert

Determine what equipment and space is needed for safe storage of chemicals.

Use approved storage cabinets, containers and safety cans for flammable liquid. (Refer to Table 5 for Container Size Limitations for Flammable and Combustible Liquids.) Maximum storage limitations are based on the size of the room, sprinklers, and fire ratings. Each lab will need to be evaluated Environmental Health and Radiation Safety for limitations.

Refrigerators and freezers used for the storage of flammable or combustible liquids must be explosion safe.

Do not store chemicals in refrigerator doors. Containers may fall when the door is opened or closed.

Use corrosion resistant cabinets for the storage of corrosives.

Use spill trays under containers of strong reagents.

Dispose of unnecessary chemicals promptly. See the Waste Disposal Section XX for additional information.

Do not store liquids above eye level.

For more information on chemical storage, contact your supervisor, instructor or the Environmental Health and Radiation Safety Department.

Table 3 - Classes of Incompatible Chemicals^a

A	B
ACIDS	BASES
1. Alkali and Alkaline Earth Metals carbides hydrides hydroxides oxides peroxides	1. Water acids halogenated organic compounds oxidizing agents Chromates, dichromates, CrO ₃ Halogens Halogenating agents Hydrogen peroxide and peroxides Nitric acid, nitrates Perchlorates and chlorates Permanganates Persulfates
2. Inorganic azides	2. Acids Heavy metals and their salts Oxidizing agents ^b
3. Inorganic cyanides	3. Acids, strong bases
4. Inorganic nitrates	4. Acids metals nitrites sulfur
5. Inorganic nitrites	5. Acids Oxidizing agents ^b
6. Inorganic sulfides	6. Acids
7. Organic compounds Organic acyl halides	7. Oxidizing agents ^b Bases Organic hydroxy compounds
8. Organic anhydrides	8. Bases Organic hydroxy compounds
9. Organic halogen compounds	9. Aluminum metals
10. Organic nitro compounds	10. Strong bases
11. Powdered metals	11. Acids Oxidizing agents ^b

^aChemicals in columns A and B should be kept separate. (i.e. A1 should be stored separate from B1.)

^bOxidizing agents include the types of compounds lists in the entry for alkali and alkali earth metals, etc.

Table 4 - Specific Chemical Incompatibilities^a

A	B
1. Acetylene and monosubstituted Acetylene (R-C ² CH)	1. Halogens Group IB and IIB metals and their salts
2. Ammonia and NH ₄ OH	2. Halogens Halogenating agents Silver Mercury
3. Carbon, activated	3. Oxidizing agents ^b
4. Hydrogen peroxide	4. Metals and their salts
5. Nitric acid	5. Metals Sulfuric acid Sulfides Nitrites, other reducing agents Chromic acid and chromates Permanganates
6. Mercury and its amalgams	6. Ammonia and NH ₄ OH Nitric Acid Acetylene Sodium azide
7. Oxalic acid	7. Silver Mercury
8. Phosphorus (yellow)	8. Oxygen Oxidizing agents ^b Strong bases
9. Phosphorus pentoxide	9. Water Halogenating agents
10. Sulfuric acid	10. Metals Chlorates Perchlorates Permanganates Nitric acid
11. Powdered metals	11. Acids Oxidizing agents ^b

^aChemicals in columns A and B should be kept separate (i.e. A1 should be stored separate from B1.)

^bOxidizing agents include the types of compounds listed in the entry for alkali and alkali earth metals, etc.

Table 5 – Maximum Allowable Container Capacity

Container Type	Flammable Liquids			Combustible Liquids	
	Class IA	Class IB	Class IC	Class II	Class IIIA
Glass	500ml (1 pt)	1 L (1 qt)	4 L (1 gal)	4 L (1 gal)	20 L (5 gal)
Metal (other than DOT drums) or approved plastic	4 L (1 gal)	20 L (5 gal)	20 L (5 gal)	20 L (5 gal)	20 L (5 gal)
Safety Cans	10 L (2.6 gal)	20 L (5 gal)	20L (5 gal)	20 L (5 gal)	20 L (5 gal)
Metal (DOT specific)	4 L (1 gal)	20 L (5 gal)	20 L (5 gal)	227 L (60 gal)	227 L (60 gal)
Polyethylene (DOT Spec. 34, UN 1H1, or as authorized by DOT exemption)	4 L (1 gal)	20 L (5 gal)	20 L (5 gal)	227 L (60 gal)	227 L (60 gal)
Pressurized liquid dispensing container	20 L (5 gal)	227 L (60 gal)	227 L (60 gal)	227 L (60 gal)	227 L (60 gal)

NOTE: This table is based on Table 6.2.3 of NFPA 30, *Flammable and Combustible Liquids Code*, except for allowable quantities of flammable liquies in metal (DOT specification) drums and pressurized liquid dispensing containers.

Class IA liquids are those having flash points (fp) below 73°F (22.8°C) and boiling points (bp) below 100 deg. F (37.8°C).

Class IB liquids are those having fp below 73°F (22.8°C) and bp at or above 100°F (37.8°C).

Class IC liquids are those having fp at or above 73°F (22.8°C) and below 100°F (37.8°C).

Class II liquids are those having fp at or above 100°F (37.8°C) and below 140°F (60°C).

Class IIIA liquids are those having fp at or above 140°F (60°C) and below 200°F (93.4°C).

Source: National Fire Protection Association, Code 45, 1975

Classification of Common Chemicals

	Flash Point	bp°C	Class
Acetone	-18°C	56°C	1B
Benzene	-11°C	80°F	1A
Carbon Disulfide	-30°C	46.5°C	1B
Diethyl ether	-45°C	34.6°C	1A
Dioxane	5-18°C	101°C	1A
Ethyl alcohol 95%	58°C	78°C	1B
Methyl alcohol	105°C	131.8°C	II
Tetrahydrofuran	1°F	66°C	1A
Methylene chloride	-97°C	40.1°C	1B
Toluene	40°F	110.6°C	1B
Xylene	77°F	139°C	1C

Contact Environmental Health and Radiation Safety for maximum allowable quantities of flammable liquids per NFPA 45. Maximum allowable limits are based on square footage of the lab and building construction.

SECTION XX - WASTE DISPOSAL

A. CHEMICAL WASTES

The disposal of chemical wastes must be conducted in accordance with procedures established by the Environmental Health and Radiation Safety Department (HM-08-001). Disposal of chemicals unless approved by the Environmental Health and Radiation Safety Department by means of the sanitary sewer system or with regular trash **is not permitted**.

The Environmental Health and Radiation Safety Department will pick up surplus or waste chemicals and arrange for proper disposal. Under normal circumstances, this service is provided at no cost for the department producing the waste. A fee may be charged for the disposal of unlabeled or unidentified waste items. Disposal containers may be obtained from the Environmental Health and Radiation Safety Department. Any container that is in good condition can be safely used to house hazardous chemical waste.

Inventories and/or labels of materials must be completed before a chemical waste pick up will be scheduled. **All hazardous waste must be labeled in the following manner:**

HAZARDOUS WASTE "CHEMICAL NAME – HAZARD INFORMATION" (i.e., HAZARDOUS WASTE "PHENOL – TOXIC, CORROSIVE")

Note: GHS Symbols can be used to convey hazard information

Do not date hazardous waste container until full, and then contact Environmental Health and Radiation Safety for next disposal date.

FOR ADDITIONAL INFORMATION AND SCHEDULING A PICKUP CONTACT THE ENVIRONMENTAL HEALTH AND RADIATION SAFETY DEPARTMENT.

B. INFECTIOUS OR BIOLOGICAL WASTES

State and local ordinances regulate the handling and disposal of infectious waste materials. The Environmental Health and Radiation Safety Department is available to assist campus personnel in determining whether a waste is infectious and in determining the proper handling procedures.

Liquid infectious waste such as blood, serum, and other body fluids can be disposed by means of the sanitary sewer. Cultures should be autoclaved in the laboratory if such a unit is available. Personnel must wear appropriate protective equipment when pouring liquid infectious waste items.

FOR ADDITIONAL INFORMATION CONTACT ENVIRONMENTAL HEALTH AND RADIATION SAFETY

Suitable containers for needles and other sharp items are available through Central Distribution.

See Section XXII, Stores Information, for list of supplies for handling infectious waste.

C. RADIOACTIVE WASTES

Federal and state regulations govern the handling and disposal of regulated radioactive materials. The Department of Radiation Safety at (419) 383-4301 is available to assist campus personnel with their radioactive disposal needs. Radioactive waste generated by research labs must be divided into two main types; dry, solid (paper products, gloves glassware, etc.) and liquid (water scintillation cocktail, etc.). These two forms of waste must then be further degraded for safe, efficient disposal.

Dry waste will be separated according to half-life. Radioisotopes with half-lives over 100 days may be grouped together (H-3, C-14). The most common radioisotopes of less than 100 day half life are S-35 (87 days), I-125 (60 days), and P-32 (14 days). These should be segregated from each other. Waste from lesser used isotopes may be discarded with isotopes of a similar half-life (Rb-

86, 18 days with P-32, 14 days). All dry waste should be placed in yellow "Radioactive Materials" bags which can be obtained from the Radiation Safety Office.

Liquid waste must be separated according to half-life as well as the type of liquid. Aqueous liquid that is non-toxic and biodegradable should be kept separate from organic liquid. Within each of these two types of liquid, radioisotopes should be segregated by half-life, the same as the dry waste. H-3 and C-14 in scintillation cocktail may be left in the counting vials.

With any form of waste, the bag or bottle should be clearly marked with the radioisotope, the amount of activity, the date of disposal, associated hazardous chemical, and the name of the approved user. The Radiation Safety Office should then be called at (419) 383-4301 to schedule a time for waste pick-up.

D. BROKEN GLASS AND EMPTY CONTAINERS

Broken glass should be cleaned up using a no-touch technique (i.e., a dustpan and sweeping tool). Broken glass should be placed in a box or other rigid, puncture-resistant container, taped shut and adequately marked as containing broken glass, before being placed with general trash items. Broken glass receptacles can be found in the research buildings Autoclave Rooms. Broken glass containers must not weigh more than 35lbs at the time of disposal. To arrange a disposal of a full broken glass container, contact environmental/building services at 419.530.1000 to submit a work order. If a broken glass container is over 35lbs or is in poor condition, the research staff are responsible for disposing of the broken glass container into the dumpster.

Empty chemicals containers should be triple rinsed, have their label be defaced, and disposed with general trash items. Containers should be resealed with the original lid or stopped before placing with general trash. Any container with more than a residual amount of chemical should be regarded as chemical waste and should be provided to the Environmental Health and Radiation Safety Department for secure disposal.

For Additional Information Contact the Environmental Health and Radiation Safety Department

E. PHARMACETICAL WASTE

All Pharmaceutical waste are classified as hazardous waste, non-hazardous waste or controlled substances. All pharmaceutical waste classified as hazardous waste will be disposed of through Environmental Health and Radiation Safety as hazardous waste. All controlled substances must be managed via procedures found at <https://www.utoledo.edu/research/rsp/RC/controlled-substances-and-dangerous-drugs/>.

Contact Environmental Health and Radiation Safety to determine which category applies to your waste streams.

Refer to Handling of Hazardous Drugs (HD) i.e., Antineoplastic and Carcinogenic Agents <http://www.utoledo.edu/depts/safety/docs/HM-08-005.pdf>.

SECTION XXI - EMERGENCY RESPONSE

A. GENERAL

Environmental Health and Radiation Safety Department personnel will assist in clean up any spills of hazardous materials. You should plan in advance for what to do in an emergency situation. What are the possible emergencies which could occur during your work (i.e. fire, spill, high level chemical exposure)? Are systems available to alert you to an emergency situation (i.e. chemical exposure monitoring system)? What supplies and equipment should you maintain in your area to assist you or emergency response personnel in the event of an emergency (i.e. eyewash and safety shower)? What training do you need to handle an emergency in your area (i.e. procedures to follow for each emergency)? Is it safe for you to work alone?

Where hazardous materials are used which, upon release, could create a hazard, spill clean up supplies should be readily available in the work area. The Environmental Health and Radiation Safety Department can assist in the selection of appropriate supplies. Certain supplies are available on spill carts and can be accessed by contacting University of Toledo Police Department.

Cleanup supplies should include neutralizing agents (such as sodium carbonate and sodium bisulfate) and absorbants (such as vermiculite and sand). Personal protective equipment should also be readily available with cleanup supplies. Commercial spill supplies are readily available from laboratory supply companies.

B. SPILL INFORMATION

Chemical Spills

1. Guidelines for bodily contact:
 - a. Skin/eye/mouth contact: wash area immediately. Use safety shower if spill covers a large area of the body. Use eye wash station to rinse eyes with copious amounts of water for at least 15 minutes.
 - b. Clothing spills: take items of clothing off immediately so that spilled material does not soak through to the skin. This includes belts and shoes (if affected).
2. Spills presenting immediate danger to life or health:

If a chemical spill takes place and, in the judgement of the person or persons responsible for such materials, poses a threat to themselves or other building occupants, the following steps should be taken:

 - a. Sound the building fire alarm so evacuation can begin.
 - b. Call 419-530-2600. Give the following information:
 - Building Name
 - Floor
 - Room Number
 - Type of Incident
 - Give name of the chemical substance involved
 - c. Evacuate the building to a safe area, leaving access for arriving emergency personnel. Do not return to the building unless instructed to do so by University of Toledo Police Department.
 - d. Obtain assistance for those injured or exposed (safety shower, medical attention, etc.)
3. Spills not immediately dangerous to life or health:
 - a. Attempt to confine the spill as much as possible if you have been trained to confine spills and are thoroughly familiar with the hazards of the spilled material. Broken glass should be cleaned up using a no-touch technique (i.e., a dustpan and sweeping tool). If you have come into contact with the spilled material, do not attempt to confine the spill until step (2) has been completed.
 - b. Remove any contaminated clothing immediately and flush all areas of bodily contact with copious amounts of water for at least 15 minutes.
 - c. Notify University of Toledo Police Department at 419-530-2600 and give them:
 - Building Name
 - Floor
 - Room Number
 - Type if Incident

- Chemical(s) involved
- Description of any injuries
- University of Toledo Police Department will then notify the appropriate response departments to assist in the clean-up of involved materials.

C. FIRE PROCEDURE

1. Upon discovering a fire, explosion or smoke in the building, call 911.. Give the following information:
 - Building name
 - Floor
 - Room number
 - Type of incident
2. After notifying 911, attempt to contain a **small fire** by utilizing available fire extinguishers **if trained to do so**. If fire is beyond control or involves potentially explosive materials, evacuate the building.
3. When a fire alarm sounds, complete evacuation is required. Walk, do not run to the nearest stairway exit and proceed to ground level. Close doors and windows as you leave. The alarm may not sound continuously. If the alarm stops, continue the evacuation and warn others who may attempt to enter the building after the alarm stops.
4. **DO NOT USE ELEVATORS DURING A FIRE EMERGENCY.**
5. Leave the building and move away from it, leaving walks and drives open for arriving fire fighters. Do not return to the building until directed to do so by police or fire fighters.
6. Someone familiar with the situation and who knows the area involved should meet the fire department.
7. Everyone must follow the orders of the Fire and Police Departments when they arrive.
8. Notify fire fighters on the scene if you suspect someone may be trapped inside building.
9. Report potential hazards or address fire prevention questions to University of Toledo Police Department.

D. HAZARDOUS GAS LEAKS IMMEDIATE DANGER (flammable, toxic, corrosive, oxygen, cryogenic)

If a gas cylinder or gas piping should begin leaking and if in the judgment of the person or persons responsible for such materials it present any danger to themselves or the other building occupants, the following steps should be taken:

1. Confine the gases or fire as much as possible to limit impact to the leak area.
2. Call 911. Give the following information:
 - Building name
 - Floor
 - Room number
 - Type of incident
3. Evacuate building to a safe area leaving access for emergency personnel. Do not return to building until instructed to do so by the Police and Fire Departments.
4. Suspected gas leaks and suspicious odors should also be reported to University of Toledo Police Department 419-530-2600 so that appropriate departments can be notified and the source of the odor investigated.

SECTION XXII – CONTROLLED SUBSTANCES, HAZARDOUS DRUGS AND LIST I/II AGENTS

A. CONTROLLED SUBSTANCES

Controlled substances may only be used for authorized medical or scientific research purposes as approved by the Federal, state or university research protocols to the extent permitted by the law. There are several requirements for use including but not limited to DEA licensing and registration, background checks, inventory and use logs, and secure storage. For more information, contact Research and Sponsored Programs at 419-530-2844.

B. LIST I/II AGENTS

List I and List II Chemicals are chemicals that can be used in manufacturing a controlled substance (i.e. anthranilic acid, ergotamine, piperidine, and drug products containing ephedrine, pseudoephedrine, or phenylpropanolamine as well as other reagents and solvents).

“Endusers” engaged in research should maintain accurate records of the intake (amount received), use and purpose of the List I and List II chemical. For example, iodine used to disinfect, each use would be difficult to measure, however recording the amount received, purpose and the number of estimated users, such as 5 students on a daily basis would be sufficient documentation. For more information, contact Research and Sponsored Programs at 419-530-2844.

C. HAZARDOUS DRUGS

In accordance with the UT Environmental Health and Radiation Safety procedure, Handling of Hazardous Drugs (HM-08-005), hazardous drugs shall be handled in a manner so as to insure the safety of the staff, patients, students, and faculty of the University of Toledo. Occupational Safety and Health Administration (OSHA) guidelines as detailed in the OSHA Instruction CPL 2-2.208: “Controlling Occupational Exposure to Hazardous Drugs” are used as a basis for this procedure. Hazardous drugs must be manipulated under local exhaust, used in a designated area, and labeled as a carcinogen or suspect carcinogen. Work surfaces must be decontaminated after use, and users should use non-powdered gloves (double layer if possible). For more information contact the Environmental Health and Radiation Safety Department at 419-530-3600.

SECTION XXIII – SAFETY AND SECURITY

PRUDENT LABORATORY SAFETY AND SECURITY PRACTICES

There is heightened concern across the nation about acts of terrorism, therefore researchers need to review laboratory safety and security procedures. To do this, researchers should:

1. Perform an audit of space and materials to assure that they are safe and secure, and not accessible to unauthorized personnel.
2. Review security and emergency response protocols, and ensure research personnel are aware of protocols and procedures. Security and emergency protocols include responses to:
 - Theft of not only valuable, but also potentially hazardous or destructive materials. Report all suspicious activity and/or theft to University of Toledo Police Department at 419-530-2600.
 - Service interruptions of power, which in turn could impact heat, lighting, fire detection and alarm systems, sprinkler systems, elevators, building water pressure, air and vacuum, fume hoods and other mechanical ventilation, biological safety cabinets, autoclaves, chemical storage cabinets and equipment used in research for controlling experiments.
 - Service interruptions of telecommunication systems including telephone and paging systems, and computer networks.
 - Service interruptions of water (impacting sprinkler systems, emergency showers and eyewashes), steam (impacting heat), natural gas, and other services provided to the laboratory.
 - Disruptions in emergency services such as police, firefighters and ambulances.

GENERAL GUIDELINES FOR LABORATORY SAFETY AND SECURITY PRACTICES

- Lock doors and windows when laboratory is unattended.
- Eliminate unnecessary quantities of chemicals, compressed gases, flammable liquids, and biological or radioactive materials.
- Maintain safe and secure storage of all hazardous substances in space you are directly responsible for and space you remotely oversee.
- Assure that spill kits are available and stocked, spill response plans are made and personnel are familiar with the plans.
- Provide flashlights for researchers who may be in rooms without emergency lighting.
- Cultivate an awareness of the potential for interrupted services and review procedures for dealing with the interruptions.
- Be aware of unexpected visitors, make inquiries and have a plan to deal with those situations. University Police are available to help develop such plans.
- Report to University Police 419-530-2600 any individuals whose behavior you find threatening or suspicious.
- Maintain accurate contact information on the REACT poster for use by emergency responders. REACT posters are available through Environmental Health and Radiation Safety.
- Wear appropriate personal protective equipment.
- Use appropriate tools and equipment for applicable procedures. Make sure that equipment is calibrated and validated.

ADDITIONAL CONSIDERATIONS FOR LABORATORIES WITH CHEMICALS

- Report all chemicals of interest, required by the Department of Homeland Security to Environmental Health and Radiation Safety through the annual survey (see [HM-08-039](#)).
- Identify materials that could create a safety hazard if warmed or cooled significantly as a result of a power outage and develop a plan for handling those materials should there be a power outage.
- Assure that compressed gas flows are fail-safe (gas supplies shut off automatically, etc.) and continuous processes shut down safely if there is a power outage.
- Regulations and campus policy require that all chemical and solvent containers be tightly sealed when not in immediate use.

ADDITIONAL CONSIDERATIONS FOR LABORATORIES WITH BIOLOGICAL MATERIALS

- Regulations and campus policy require that all laboratories using plant/animal/human pathogens, recombinant DNA, human cell cultures or human-derived products, nonhuman primate materials, or biotoxins be registered with the Institutional Biological Safety Committee.
- All cultures, stocks, and other regulated wastes must be decontaminated before disposal by an approved decontamination method such as autoclaving. Materials to be decontaminated outside of the immediate laboratory are to be placed in a durable, leakproof container and closed for transport from the laboratory.
- "Sharps" include items that may be especially hazardous and must be handled with special precautions. All sharps must be handled in accordance with the campus sharps disposal policy.

ADDITIONAL CONSIDERATIONS FOR LABORATORIES WITH RADIOACTIVE MATERIALS

- Regulations and campus policy require that all radioactive materials, including samples and waste materials, must be kept secure at all times.

Remember, it is the responsibility of the departmental head to ensure the safety and security of faculty, staff, students and visitors.

OSHA LAB STANDARD

29 CFR 1910.1450

(a)

Scope and application.

(a)(1)

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

(a)(2)

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

(a)(2)(i)

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

(a)(2)(ii)

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

(a)(2)(iii)

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

(a)(3)

This section shall not apply to:

(a)(3)(i)

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

(a)(3)(ii)

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

(a)(3)(ii)(A)

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

(a)(3)(ii)(B)

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

(b)

Definitions –

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

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

Carcinogen (see *select carcinogen*).

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

Chemical Hygiene Plan means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting

employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

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

- (i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or
- (ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg. C) regardless of the pressure at 70 deg. F (21.1 deg. C); or
- (iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 C) as determined by ASTM D-323-72.

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

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

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

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

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

- (i) **Aerosol, flammable** means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;
- (ii) **Gas, flammable** means:
 - (A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or
 - (B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
- (iii) **Liquid, flammable** means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.
- (iv) **Solid, flammable** means a solid, other than a blasting agent or explosive as defined in § 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

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

- (i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24 - 1979 (ASTM D 56-79)) - for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or
- (ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7 - 1979 (ASTM D 93-79)) - for liquids with a viscosity equal to or greater than 45 SUS at 100 deg. F (37.8 deg. C), or that contain suspended solids, or that have a tendency to form a surface film under test; or
- (iii) Setaflash Closed Tester (see American National Standard Method of test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)). Organic peroxides, which undergo autoaccelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

Hazardous chemical means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes. Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

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

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

Laboratory-type hood means a device located in a laboratory, enclosure on five sides with a movable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

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

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

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

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

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

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

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

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

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

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

- (i) It is regulated by OSHA as a carcinogen; or
- (ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP)(latest edition); or
- (iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or
- (iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
 - (A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3);

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

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

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

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

(c)

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

(d)

Employee exposure determination

(d)(1)

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

(d)(2)

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

(d)(3)

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

(d)(4)

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

(e)

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

(e)(1)

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

(e)(1)(i)

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

(e)(1)(ii)

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

(e)(2)

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

(e)(3)

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

(e)(3)(i)

Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

(e)(3)(ii)

Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

(e)(3)(iii)

A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

(e)(3)(iv)

Provisions for employee information and training as prescribed in paragraph (f) of this section;

(e)(3)(v)

The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

(e)(3)(vi)

Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

(e)(3)(vii)

Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee; and

(e)(3)(viii)

Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

(e)(3)(viii)(A)

Establishment of a designated area;

(e)(3)(viii)(B)

Use of containment devices such as fume hoods or glove boxes;

(e)(3)(viii)(C)

Procedures for safe removal of contaminated waste; and

(e)(3)(viii)(D)

Decontamination procedures.

(e)(4)

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

(f)

Employee information and training.

(f)(1)

The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

(f)(2)

Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

(f)(3)

Information. Employees shall be informed of:

(f)(3)(i)

The contents of this standard and its appendices which shall be made available to employees;

(f)(3)(ii)

the location and availability of the employer's Chemical Hygiene Plan;

(f)(3)(iii)

The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;

(f)(3)(iv)

Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

(f)(3)(v)

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

(f)(4)

Training –

(f)(4)(i)

Employee training shall include:

(f)(4)(i)(A)

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

(f)(4)(i)(B)

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

(f)(4)(i)(C)

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

(f)(4)(ii)

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

(g)

Medical consultation and medical examinations.

(g)(1)

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

(g)(1)(i)

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

(g)(1)(ii)

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

(g)(1)(iii)

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

(g)(2)

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

(g)(3)

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

(g)(3)(i)

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

(g)(3)(ii)

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

(g)(3)(iii)

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

(g)(4)

Physician's written opinion.

(g)(4)(i)

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

(g)(4)(i)(A)

Any recommendation for further medical follow-up;

(g)(4)(i)(B)

The results of the medical examination and any associated tests;

(g)(4)(i)(C)

Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace; and

(g)(4)(i)(D)

A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

(g)(4)(ii)

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

(h)

Hazard identification.

(h)(1)

With respect to labels and Safety Data Sheets:

(h)(1)(i)

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

(h)(1)(ii)

Employers shall maintain any Safety Data Sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

(h)(2)

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

(h)(2)(i)

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

(h)(2)(ii)

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

(h)(2)(iii)

If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of Safety Data Sheets and labeling.

(i)

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

(j)

Recordkeeping.

(j)(1)

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

(j)(2)

The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.1020.

(k)

Dates --

(k)(1)

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

(k)(2)

Start-up dates.

(k)(2)(i)

Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.

(k)(2)(ii)

Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

(l)

Appendices – The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation. [55 FR 3327, Jan. 31, 1990; 55 FR 7967, March, 6, 1990; 55 FR 12777, March 30, 1990; 61 FR 5507, Feb. 13, 1996]