CHEMICAL HYGIENE PLAN

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List of Acronyms

CHO	Chemical Hygiene Officer
IBC	Institutional Biosafety Committee
MSU	Missouri State University
OSHA	Occupational Safety & Health Administration
PI	Principal Investigator
PPE	Personal Protective Equipment
RSO	Radiation Safety Officer
SDS	Safety Data Sheets
SOP	Standard Operating Procedure

Emergency Phone Numbers

Fire/ Police/ Emergency Medical	911
Poison Control Center	800-222-1222
MSU Safety & Transportation	836-5509
Taylor Health	836-4000
MSU Environmental Management	836-8334/ 836-3108

1.0 PURPOSE & SCOPE

The purpose of the Chemical Hygiene Plan is to establish procedures to protect all employees from health/physical hazards associated with the use of hazardous chemicals in the laboratory. This plan was developed in accordance with the US Occupational Safety & Health Administration's (OSHA) Laboratory Standard (29 CFR 1910.1450)., The OSHA Standard defines a laboratory as a facility where the "laboratory use of hazardous chemicals" occurs; anywhere relatively small quantities of hazardous chemicals are used on a non-production basis. This definition may include photo labs and art studios.

This plan applies to all Missouri State University (MSU) faculty, staff, student employees, and associates working with or around laboratory operations involving hazardous chemicals who are not covered by a Department-specific plan. Each laboratory employee is expected to be familiar with and operate in accordance with the procedures outlined in this plan. The plan will be available for review; a copy will be accessible on the Environmental Management website, it is recommended that each Department maintain a hard copy in the departmental office. Each department is expected to maintain Safety Data Sheets (SDS) at a location accessible to all employees.

A list of specific terms and definitions used in this plan is provided in Appendix B.

2.0 RESPONSIBILITIES

Department Head: The department head is responsible for chemical hygiene in the laboratory. This person shall insure:

1. Laboratory employees know and follow the chemical hygiene rules.
2. Appropriate training is provided and protective equipment is available and in working order.
3. Facilities and training for use of any material being ordered are adequate.
4. Routine and periodic checks are conducted of emergency equipment, chemical hygiene, and departmental housekeeping.

Laboratory Employee: Each University/laboratory employee is responsible for planning and conducting all operations in accordance with the chemical hygiene procedures, and developing good personal chemical hygiene habits. Principal investigators/instructors with direct oversight of laboratories are responsible for ensuring the health and safety of subordinate staff and students in the laboratory setting, allowing no students to work in their lab prior to appropriate training requirements.

Chemical Hygiene Officer: The Director of Environmental Management serves as MSU's Chemical Hygiene Officer (CHO). Each department should assign their own CHO. Responsibilities of the CHO include:

1. Monitor use and disposal of chemicals used in the laboratory setting.

2. Assist departments/individual laboratories in developing precautions and adequate facilities.
3. Keep up to date on the current legal requirements concerning regulated substances.
4. Periodically review the Chemical Hygiene Plan and update as appropriate.

Departmental CHOs will have immediate control and responsibility for chemical safety within their laboratories.

3.0 GENERAL LABORATORY PROCEDURES

The following rules are appropriate for essentially all laboratory work with chemicals:

- Employees shall act in a professional manner at all times.
- Horseplay and practical jokes are forbidden.
- Avoid working alone.
- Know as much as possible about the chemical you are handling. Acquire information from container labels, SDS, literature, or discussing chemical properties with peers.
- Be aware of the location and proper operation of laboratory safety equipment.
- Use appropriate personal protective equipment (PPE) based on the hazards of the materials in use. Additional detail on PPE use and selection is provided in Section 4.0.
- Avoid 'routine' exposures:
  i. Take necessary precautions to avoid skin contact with chemicals.
  ii. Do not smell or taste chemicals.
  iii. Never pipette by mouth. Use a vacuum or a pipette bulb.
  iv. Apparatus that may discharge toxic chemicals must be vented into local exhaust devices.
  v. Choose only those chemicals for which the quality of the available ventilation system is appropriate.
- Eating, drinking, smoking, gum chewing, and cosmetic application are not permitted.
- Food or drinks may not be stored in a refrigerator with chemicals. Glassware or utensils that are used for laboratory operations may not be used for storage, handling, or consumption of food or beverages.
- Ice machines or containers that have been used for storage of chemicals shall not be used for food storage.
- Confine long hair and loose clothing. Wear closed-toe shoes at all times; open-toe shoes are prohibited in the laboratory. Low-heeled shoes and pants are preferred.
- Handle and store lab glassware with care to avoid damage; do not use chipped or cracked glassware.
- Use equipment only for its designated purpose.

- Hands shall be washed before using the restrooms and before eating or smoking. Areas of exposed skin (e.g. forearms) should be washed frequently if there is potential of contact with chemicals.
- Be alert to unsafe conditions and report them to your supervisor or department head.
- Chemical fume hoods should be used for any operations which might result in release of toxic chemical vapors or dust.
- Proper procedures for transporting chemicals within the department include using secondary containers, such as using rubber or plastic bottle carriers to transport corrosive materials.
- Any food materials, opened or closed, are considered chemical supply when brought into a laboratory. Label all with "not for human consumption".
- Only well understood reactions shall be permitted to run unattended. Lights should be left on and appropriate signage placed on the door. Provisions for containment of toxic substances in the event of a utility service failure (such as cooling water) to an unattended operation should be established.
- Accidents and spills:
    i. Eye contact- promptly flush eyes with water for a minimum of 15 minutes and seek medical attention.
    ii. Skin contact- promptly flush affected area with water and remove any contaminated clothing. If symptoms persist after washing, seek medical attention.
    iii. Ingestion-drink large amounts of water unless contraindicated by the SDS or a physician.
    iv. Immediately clean up any spills; notify your supervisor or the Environmental Management Department if assistance is needed.
- Visitors are to be escorted by a laboratory employee and are the responsibility of that employee. University staff members performing routine, daily duties are excluded from this requirement.

3.1 HOUSEKEEPING

1. Access to exits, emergency equipment, and utilities must never be blocked. Coats, bags, and other personal items must be stored in the proper area, not on bench tops or in aisles.
2. Properly label chemicals and equipment for use and storage. Repair or replace any damaged labels immediately. Secondary containers must be labeled with the chemical name, manufacturer's name, hazard class, and any other special warnings.
3. The floors should be cleaned on a regular basis. Promptly wipe up all liquid spills and ice on the floor.
4. Keep work areas clean and uncluttered. Bench tops and hoods should remain clear of broken glass, spilled chemicals, paper litter, etc.

5. Chemical hazards should be maintained at least two inches from the edge of the bench tops.
6. Do not conduct unattended experiments without the authorization and prior approval of the instructor or PI.
7. Do not store materials or chemicals directly on the floor.
8. Do not block the sink drains. Rubber matting in the bottom of the sinks is recommended to help prevent breakage of glassware and avoid injuries.
9. Wear appropriate gloves to clean glassware. Handle and store laboratory glassware with care. Promptly discard cracked or chipped glassware.
10. Clean up work areas at the end of the operation or day.
11. Properly dispose of broken glass and sharps (i.e., needles and razor blades). If broken glassware is contaminated with a hazardous substance, the glassware may need to be treated as a hazardous substance. Consult Environmental Management.
12. To avoid accidents, drawers and cabinets must be kept closed.
13. Properly dispose of all waste chemicals. Never pour waste chemicals down the drains.
14. It is the responsibility of the instructor of each lab to make sure all equipment and glassware are put away, bench tops and hoods are cleaned, and no unlabeled chemical residues are left in glassware or on tables before the following lab starts.

3.2 INSPECTIONS

Formal housekeeping and regulatory compliance inspections may be conducted at any time by Environmental Management, and findings will be shared with the Department Head. Regular internal inspections by the Departmental CHO and/or the Departmental Safety Committee are highly recommended.

4.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The instructor/ PI (or designee) shall be responsible for the selection/acquisition of appropriate PPE, maintaining availability, and establishing cleaning and disposal procedures. Basic PPE for MSU laboratories consists of lab coats, eye protection, and gloves. PPE shall be inspected before each use and should be removed before leaving laboratory areas.

Eye Protection

Eye protection will be worn when deemed necessary by the instructor/PI in charge of the laboratory. Eye protection used in MSU laboratories must at a minimum meet the requirements of ANSI Z87.1. Chemical splash goggles are recommended when working with chemicals, glassware, or heat. Face shields are recommended when transferring or pouring acidic or caustic materials.

Contact lenses should not be worn in the laboratory; chemicals can be concentrated under contact lenses and contact lenses will interfere with eye flushing in case of emergency. If the employee needs to wear contact lenses (e.g. if the vision deficiency cannot be corrected with glasses), then chemical splash goggles should be worn over the contact lenses.

Gloves

Appropriate chemical resistant gloves shall be worn whenever the potential for hazardous skin contact exists. The SDS for the substance or glove selection charts should be referenced for glove selection. Special use gloves may include the use heat resistant gloves for handling hot objects or abrasion resistant gloves (e.g. Kevlar cut resistant gloves, leather gloves) for handling broken glass or for other potentially abrasive situations. Note that these special use gloves are not chemical resistant, and must NOT be worn when handling chemicals.

Remove gloves if they become damaged during use, or before touching other surfaces (e.g. door knobs, faucet handles).

Clothing

Laboratory coats should be worn when working in the laboratory. Lab coats should be inspected for damage, deterioration, or contamination prior to each use, and cleaned or replaced as necessary. Remove the lab coat immediately if significant contamination occurs.

4.1 HEARING PROTECTION

1. Hearing protection devices (e.g. ear plugs) are required whenever employees are exposed to an 8-hour time-weighted average (TWA) of 85 dBA or greater.
2. An 85 dBA or greater TWA lab environment would trigger mandatory compliance with all facets of OSHA's Occupational Noise Exposure Standard (29 CFR 1910.95).

4.2 RESPIRATORS

1. Prior to the use of any respirators, a review of all optional engineering controls should be conducted to try to eliminate the need for respirator use.
2. If no engineering control is available, any respirator use must be in accordance with the department's Voluntary Respirator Use program [referencing 29 CFR 1910.134(c)(2)].

4.3 TRAINING

1. Employees shall not use any PPE until they have received instruction on the proper selection, use, and limitations of the equipment.

2. It is the responsibility of the department head (or PI) to ensure proper training has been provided.

5.0 HAZARD IDENTIFICATION

1. All chemical containers must have a legible label describing contents.
2. Unlabeled products should not be stored anywhere in the department.
3. Labels on incoming containers of hazardous chemicals shall not be removed or defaced.
4. *Safety Data Sheets*. Each department shall maintain SDSs for chemicals in use within the department. A hard copy file (or binder) should be kept in a designated area where the SDSs are available at all times. Contact Environmental Management for additional information on acquiring and maintaining SDSs.
    i. SDSs may be obtained from chemical manufacturers or suppliers (for example: Sigma-Aldrich, Fisher Scientific, Flinn Scientific).
5. A hazard review of new materials not previously used in the laboratory should be completed before actual handling has begun. This review should be conducted by the PI and laboratory worker.
6. Chemical substances developed in the laboratory shall be assumed to be hazardous in the absence of other information.

If a chemical substance is produced in the laboratory for another user outside Missouri State University, the SDS and labeling provisions of the OSHA Hazard Communication Standard apply. The CHO must be contacted to ensure these requirements are met.

6.0 ENVIRONMENTAL MONITORING

Laboratory employee exposures shall not exceed permissible exposure limits specified in 29 CFR 1910, Subpart Z.

1. Employee exposures to any substance regulated by an OSHA standard shall be measured when there is reason to believe that exposure levels routinely exceed the action levels.
2. The CHO should be consulted for assistance with environmental monitoring.
3. The CHO will notify employees of monitoring results.

7.0 EMERGENCY EQUIPMENT

7.1 GENERAL

Emergency equipment is located throughout the various laboratories and stockroom. Laboratory Supervisors are responsible to ensure that each laboratory employee is familiar with the location, application, and correct ways to operate the following equipment:

Fire extinguishers*	Fire Blankets
Fire alarms	Fire Doors
Safety showers	Smoke detectors
Eye wash stations	First aid kits
Chemical spill kits	

**Fire extinguisher training for laboratory workers is highly recommended.*

7.2 SAFETY SHOWERS/ EYEWASH STATION

1. Safety showers and eyewashes should be within the work area for immediate emergency use.
2. Inspections
    a. Weekly
        - Safety showers and eyewash stations should be flushed weekly by a laboratory employee.
    b. Annual
        - The Environmental Management Department will conduct an annual inspection of all safety showers and eyewash stations, primarily to ensure functionality.

7.3 FIRE EXTINGUISHERS

1. Fire extinguishers must be located appropriately within each laboratory.
2. Access must be maintained and the location should be marked as appropriate.
3. The fire extinguisher type and size shall be selected for the appropriate hazards.
4. Monthly inspections conducted by designate:
    - Each extinguisher is in its designated location.
    - Unimpeded access is maintained.
    - The pin is in place and attached with an unbroken wire.
    - Check to ensure the indicator gauge is full.
    - Check for evidence of physical damage
5. Annual inspections conducted by outside contractor via Safety and Transportation Department:
    - Copies of annual inspections and scheduled maintenance are maintained in the Safety and Transportation Department.

7.4 FIRST AID KITS

1. Maintenance of first aid kits is recommended for prompt treatment of minor injuries or for short-term emergency treatment before getting medical assistance.
2. Department heads or PI's have oversight on inspecting and maintaining first aid supplies in their respective areas.

8.0 EMERGENCY PROCEDURES

8.1 INJURIES

1. For serious injuries, contact Public Safety at 911 or 836-5509 immediately.
2. Do not move an injured person unless he or she is in danger of further harm.
3. If chemicals have been spilled on the body or splashed in the eyes, flood the exposed area(s) with running water for fifteen minutes, and remove contaminated clothing.

8.2 CHEMICAL RELEASES

In addition to the following procedures, specific chemical spill information may be found on container labels and SDSs.

1. Major Spills
   a. Alert nearby personnel.
   b. Sound the building alarm and evacuate the building.
   c. Confine the spill if possible.
   d. Contact Public Safety at 911 immediately.
2. Minor Spills – Liquids
   a. Confine the spill to a small area.
   b. Avoid breathing vapors of the spilled material.
   c. Clean up the spill and label per Section 17.4.
   d. Follow proper waste disposal procedures (Section 17.4).
3. Minor Spills – Solids
   a. Sweep solids of low toxicity into a dust pan and place into proper container for disposal (Section 17.4).
   b. Cleaning minor spills of toxic solids will require cleanup measures as prescribed on the chemical's SDS.
4. Leaking Compressed Gas Cylinders
   a. If the leak cannot be stopped by tightening the valve, the supplier (Praxair Distribution) shall be contacted as soon as possible.
   b. If it can be done so safely, remove and isolate the cylinder into a well-ventilated safe area. Notify Public Safety at 911.

For more information see Hazardous Waste/Hazardous Materials Contingency Plan.

8.3 FIRES AND EXPLOSIONS

1. A fire in a small vessel oftentimes could be suffocated by covering the vessel with an inverted beaker or a watch glass. Employees trained on the usage of fire extinguishers may use an extinguisher to put out a small fire; direct the discharge at the base of the flame using a sweeping motion. Consultation of the extinguisher's label is necessary to ascertain the class(es) of fires it is effective against:
   - Class A fires: Ordinary combustible solids such as paper and textiles.
   - Class B fires: Flammable liquids.

- Class C fires: Electrical fires.
- Class D fires: Reactive metals.

2. The following emergency procedures shall be followed in the event of larger fires or explosions:
    a. Alert nearby personnel.
    b. Confine the emergency if possible.
    c. Call Public Safety at 911 immediately.
    d. Sound the building alarm and evacuate the building.

9.0 ACCIDENT REPORTING/ RECORDKEEPING

1. Injuries requiring medical attention must be reported immediately and appropriate medical treatment provided.
2. Report accidents resulting in injury or property damage, such as spills to Public Safety and Department Safety Chair.
3. Accident/incident records shall be accumulated and maintained the by Departmental Safety Chair/CHO. Occupational medical records shall be retained for the duration of employment plus thirty years.

10.0 MEDICAL PROGRAM

1. Medical surveillance, including medical consultation and follow-up, shall be provided under the following circumstances;
    a. Where exposure monitoring is over the action level for an OSHA regulated substance that has medical surveillance requirements.
    b. Whenever a laboratory employee develops signs or symptoms that may be associated with a hazardous chemical resulting from exposure in the laboratory.
    c. Whenever a spill, leak, or explosion results in the likelihood of a hazardous exposure, as determined by the CHO.
2. All examinations shall be provided by a licensed physician or under the direct supervision of a licensed physician, at no cost to the employee, without loss of pay, and conducted at a reasonable time and place. Except in extreme cases, student employees should be referred first to Taylor Health and Wellness Clinic.
3. Where medical consultations or examinations are provided, the examining physician shall be provided with the following information:
    a. The identity of the chemical(s) to which the employee(s) may have been exposed; *very likely the attending physician will seek a copy of the SDS for the chemicals—supervisors should make arrangements to forward these documents promptly.*
    b. A description of the conditions under which the exposure occurred.
    c. A description of the signs or symptoms of exposure that the employee is experiencing.
4. For examinations or consultations provided to employees, a written opinion from the examining physician shall be obtained by individuals representing Taylor Health and Wellness and shall include the following:

a. Recommendations for further medical follow-up.
b. Results of the examination and associated tests
c. Any medical condition revealed that places the employee at an increased risk of exposure to a hazardous substance found in the workplace.
d. A statement that the employee has been informed of the results of the examination or consultation.

**Accidents or injuries that occur in the laboratory and require medical attention must be treated immediately. Chemical incidents must be reported promptly to the Safety and Transportation Department 836-5509.*

11.0 STANDARD OPERATING PROCEDURES

This section provides generalized standard operating procedures (SOPs) for the laboratory. Each organizational entity or PI should develop written SOPs specific to their operation. Safe work practices and selection and use of personal protective equipment should be an integral part of the lab safety procedures.

11.1 PLANNING CHEMICAL LABORATORY EXPERIMENTS

1. Seek information about potential hazards, plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation.
2. List all possible reactions including side-reactions before beginning.
3. Follow recognized safe practices concerning protective equipment, housekeeping, handling of hazardous chemicals, and utilization of equipment as outlined in this chemical hygiene plan.
4. If conducting an unknown reaction, always start with small quantities of material and carefully observe reaction characteristics such as temperature, color, viscosity, and physical state.
5. Obtain safety (exposure routes) and chemical characteristics information (pH, flash point, vapor pressure, etc) about reactants and by-products.
6. As necessary and applicable, provide adequate cooling, ventilation, pressure relief, and gas purging. Isolate the reactive vessel and conduct frequent inspections of equipment during reaction. *Do not leave a hazardous system unattended.*
7. The lab worker needs to pre-plan the reaction itself; common questions are “How violent will the reaction be?”, “What is the effect of catalysts or inhibitors?” “Will water or air affect the reaction?”
8. SOPs should be in place for electric power failure, cooling system failure, water and/or air leaks into the system, or release/spill of reaction contents.
9. Note that explosions, fires, or asphyxiation could be caused by the accidental combination of potentially dangerous substances.

12.0 CHEMICAL PROCUREMENT AND STORAGE/INVENTORY

12.1 PROCUREMENT

1. Departments are responsible for procurement of chemicals within their laboratories via approval from department head or designee. *Prior* to purchasing, the following must be considered:
    a. Proper storage and handling procedures;
    b. Proper disposal procedures;
    c. Adequate facilities to safely handle the hazardous chemicals;
    d. Adequately trained personnel.
2. Before a substance is received, information on proper handling, storage, and disposal shall be known to those who will be involved.
3. No container shall be accepted without an adequate identifying label. The label shall include as a minimum the substance name, an appropriate hazard warning, and specific target organ effects.
4. All containers must be received in a central location, the Chemistry Stockroom.
5. Purchasers are encouraged to check the Chemical Exchange Program under the Environmental Management website for surplus chemicals that may be available. Materials requested from Chemical Exchange are provided at no cost to the user.

12.2 STORAGE/INVENTORY

1. Minimize storage and working amounts of hazardous chemicals.
2. All chemical containers must have a legible firmly attached label, containing the following information: chemical name written out, concentration or purity, hazard information, name of manufacturer or name of preparer, and date of preparation or received. See Appendix D for NFPA guidelines.
3. Chemicals shall be stored in containers that are chemically compatible.
4. Chemical reagents shall be kept in closed containers when not in use.
5. All flammable substances with NFPA rating of 3 or 4 shall be stored safely in designated storage units (e.g. flammable storage cabinet) and corrosives in corrosive cabinet when possible. Poisons with a NFPA rating of 3 or 4 shall be stored in a locked cabinet in the storeroom.
6. Store in appropriate designated locations; hazardous chemical storage in offices is prohibited.
7. Compressed gas cylinders must be secured by three points of contact at all times (chain, wall or other cylinder). Caps shall be in place on cylinders not in use.
8. Incompatible chemicals must be segregated; a partial listing of incompatible chemicals is included in Appendix C.
9. Departments are responsible for maintaining and updating an inventory of chemical stocks. Inventories should be available upon request to Environmental Management.
10. Surplus, out-of-date, or no longer needed chemicals should be removed from the laboratory. Examine stored chemicals annually for deterioration and chemical

integrity. Chemicals that are still viable should be submitted to the chemical exchange program; out-of-date or adulterated chemicals should be submitted for disposal per Section 17.4.

11. Label all chemicals with a received date.
12. Do not store chemicals under a fume hood, which decreases the efficiency of the fume hood.
13. Chemicals should not be stored on the floor without secondary containment.
14. Flammables can only be stored in a refrigerator that is explosion proof.
15. Never store chemicals over or near a sink.

13.0 GENERAL CHEMICAL HANDLING PROCEDURES

General chemical handling procedures, including recommended storage and control methods, are included in the table below. This should be considered a general guide only, and is not a substitute for specific chemical information available from product labels and SDSs.

Table 1
General Chemical Handling Procedures

Flammable Liquids/Solvents			
Hazards	***Storage***	***Controls***	***Examples***
• Fire • Respiratory • Skin contact • Eyes	• Store in approved flammable cabinet • Maintain 'in use' quantities at a minimum	• Wear proper PPE • Use fume hood • Proper grounding when transferring to/from metal containers • Clean spills immediately	Acetone Ethanol Isopropyl Alcohol Hexanes

Corrosives			
Hazards	***Storage***	***Controls***	***Examples***
• Respiratory • Skin contact • Eye contact	• Utilize secondary containment • Transport in chemical carrier • Store away from incompatibles • Clean drip tray often	• Wear proper PPE • Flush any body contact areas with water immediately • When diluting, *always add acid/base to water*	Nitric Acid Sulfuric Acid Sodium Hydroxide Hydrochloric Acid
Toxic Materials			
Hazards	***Storage***	***Controls***	***Examples***
• Inhalation • Ingestion • Potential for skin absorption	• Maintain minimum quantity necessary • Store as indicated by manufacturer or supplier	• Use fume hood as possible • Clean spills immediately	Lead Mercury Ethidium Bromide Methylene Chloride

Reactive Materials

Hazards	*Storage*	*Controls*	*Examples*
• May react violently with water • Pyrophors: potential ignition if exposed to air	• Store as indicated by manufacturer or supplier • Store pyrophors in inert gas or under oil (exclude ambient air)	• Wear proper PPE • Take precautions per manufacturer • Use fume hood • Use blast shield when necessary	Sodium metal Potassium metal Phosphorous

Compressed Gases

Hazards	*Storage*	*Controls*	*Examples*
• May be flammable, toxic, or corrosive • Cylinders contain large amounts of stored energy; may cause serious injury/ damage	• Store in upright position, secured to permanent structure with strap or chain • Keep caps in place when not in use	• Transport with cap in place, using gas cylinder dolly • Use only appropriate fittings and regulators • Use check valves to avoid cross-contamination • Open valves slowly and carefully	Hydrogen Argon Nitrogen Carbon Dioxide

Reproductive Toxins/ Carcinogens/ High Acute Toxicity Chemicals

Hazards	*Storage*	*Controls*	*Examples*
• Chromosomal damage/ adverse reproductive outcomes • Effective exposure response times very short	• Store in isolated and secure area • Maintain minimum quantity necessary	• Work in designated area (refer to Section 14.0) • Wear proper PPE • Utilize adequate engineering controls (fume hood/ glove box)	Arsenic Benzene Vinyl Chloride

Peroxide Formers			
Hazards	***Storage***	***Controls***	***Examples***
• Shock sensitive and may detonate when peroxide crystals are formed	• Limit exposure to air, light, heat, moisture and contamination from metals • Label bottles with date opened and use test strips often	• When possible, purchase with a peroxide formation inhibitor • Do not touch or open when white crystals are observed	Tetrahydrofuran Diethyl ether

Cryogens			
Hazards	***Storage***	***Controls***	***Examples***
• Cryogenic burns can be caused by splashing or spills • Cylinders contain large amounts of stored energy; may cause serious injury/ damage • Asphyxiation is possible if there is not adequate ventilation	• Liquid helium must be kept in specially designed storage or transport vessels • Liquid nitrogen may be transported using a proper dewar for cryogens	• Proper PPE (cryo gloves, close toe shoes, and goggles) • Sufficient ventilation • Proper use of storage dewars	Liquid nitrogen liquid helium

13.1 SUBSTANCES OF HIGH CHRONIC/HIGH ACUTE TOXICITY

RADIOACTIVE MATERIALS

The use of radioactive sources and radiation-producing equipment is strictly regulated by the Nuclear Regulatory Commission (NRC), Missouri Department of Health and Senior Services' (MDHSS), and Missouri Radiation Control Program (MRCP). Radioactive sources at Missouri State University are licensed through the NRC; users of any radioactive source or radiation-producing instrument are responsible to notify the University's Radiation Safety Officer (RSO) for authorization before purchasing or bringing any radiation source on campus.

14.0 DESIGNATED AREAS

A designated area must be established for work with "select carcinogens", reproductive toxins, and substances that have a high degree of acute toxicity. The following procedures must be developed for all work with select carcinogens, reproductive toxins, and substances of high acute toxicity:

a. The establishment of a 'designated area'. This may be an entire laboratory or a device in the laboratory, such as a hood. This area must be clearly marked.
b. Required approvals for conducting this project.
c. Control equipment in place as required (e.g. fume hood/ biological safety cabinet).
d. Proper storage procedures.
e. PPE availability.
f. Retention of records on amounts of these substances on hand, and the names of workers involved.
g. Spill prevention, emergency response, decontamination, and waste disposal.

15.0 OPERATIONS REQUIRING PRIOR APPROVAL

Certain laboratory operations are of special concern because of the potential hazards associated with them (for example: rDNA work requiring approval from Institutional Biosafety Committee (IBC), or working with radioisotopes requiring by formal approval from the NRC). In these instances laboratory personnel are instructed to obtain prior approval from the appropriate committee or agency prior to commencing the operation.

For this department, these procedures include the principal investigator first contacting the CHO for approval and additional information.

16.0 VENTILATION

16.1 GENERAL GUIDELINES

General laboratory ventilation should provide air flow into the laboratory from non-laboratory areas and out to the exterior of the building.

1. All laboratory doors should remain closed, except when used for entrance or egress.
2. All reactions that produce unpleasant and/or potentially hazardous fumes, vapors, or gases shall be run with local exhaust ventilation (e.g. fume hoods).
3. Reactions with corrosive fumes should be conducted in a hood lined with corrosion-resistant material.
4. The sash of the hood should be lowered to within 6" of the floor of the hood when in use. This achieves an effectiveness of the hood ventilation system as well as providing a barrier between the chemical reaction and worker.

16.2 FUME HOOD MAINTENANCE AND INSPECTIONS

Daily (or prior to each use) lab employees working with chemicals should do the following:

- Visually inspect the hood area and remove storage and other visible blockages.
- Check that the pressure gauge (manometer) is functioning.

Each department is responsible to see that hoods are inspected at least annually to verify that face velocities are adequate to meet manufacturer recommendations. Work orders should be submitted to Facilities Maintenance for hoods that appear to be malfunctioning or do not meet adequate manufacturer face velocities.

16.3 VENTILATION FAILURE

In the event of a ventilation equipment failure, lab employees will:

1. Shut down all experiments or chemical operations, if possible.
2. Notify Facilities Management to initiate repairs immediately.
   a. Improperly functioning equipment, out of service equipment, and equipment under repair shall be locked and tagged out and not restarted without the approval of the Facilities Maintenance.
3. If the failure will result in a hazardous situation such as the release of a hazardous vapor to general areas of the building, contact Public Safety and evacuate the area.

17.0 WASTE DISPOSAL

17.1 BROKEN GLASS

Broken glass (e.g. beakers, pipettes, flasks) should be promptly swept up and disposed in designated broken glass containers. If the container spills chemical contents, refer to Section 17.4.

17.2 BROKEN THERMOMETERS

The University strongly encourages the removal of all mercury thermometers in order to eliminate the potential for mercury exposure to laboratory workers. Standard mercury thermometers may be exchanged for alcohol thermometers at no cost; to exchange/dispose of mercury thermometers contact the Environmental Management Department.

1. Entities that choose to keep mercury thermometers are expected to have mercury spill kits on hand, and to train laboratory workers in the use of the spill kits. Contact Environmental Management in the event of a mercury thermometer break.
    a. Thermometer pieces *and* all mercury cleanup material must be placed in a suitable container and disposed per Section 17.4.
2. Glass from broken alcohol thermometers should be placed in designated containers per Section 17.1. No other cleanup or notification is necessary.

17.3 CHEMICAL WASTES

Employees working in the laboratory are responsible for ensuring chemical wastes are managed properly while they are in the lab. In-lab waste storage areas, or Satellite Accumulation Areas (SAAs), are regulated by Federal/State law. General procedures for waste containers in SAAs are listed in Section 17.4.

17.4 WASTE DISPOSAL PROCEDURES

To properly manage hazardous waste with respect to treatment, transportation, and ultimate disposal, it is necessary to identify the waste and its properties. Chemical analysis for identification purposes is time-consuming and costly. At Missouri State University, the Environmental Management Office utilizes the knowledge and expertise of those involved in the generation of waste to aid in its identification. In order to enable Environmental Management to effectively classify and manage these wastes, the cooperation of everyone involved is essential.

1. Containers
    - Chemical waste must be placed in appropriate containers, and containers must remain sealed at all times, except when adding waste.
    - Flasks, beakers, and other non-sealing lab items are not considered appropriate waste containers and should never be labeled with the word “waste”.

2. Labeling
   - Labels must be securely affixed to the container.
   - Information on the label must include name of class (or instructor) generating the waste, start accumulation date, room number and all chemicals in the waste.
   - List chemicals out by name, do not label by chemical formula or with structures, etc.
3. Disposal
   - Fill out the web submission form (*www.missouristate.edu/environmental/24684.htm*) to make arrangements for hazardous chemicals to be removed.
   - Do not dispose of hazardous chemicals in the trash or flush down the drain. Sink flushing or discarding of non-hazardous chemicals shall be evaluated on a case-by-case basis via direction from the CHO or department-appointed designee.
   - Fume hoods may not be used as a vehicle for releasing volatile chemicals.

18.0 EMPLOYEE TRAINING

All laboratory employees will receive training related to the hazards of chemicals present in their work area. Training will 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 training shall be provided by the PI and/or CHO of department.

The training should include the elements covered in this Chemical Hygiene Plan as well as any procedures unique to the specific laboratory. Training topics include:

- General laboratory procedures
- Selection and proper use of PPE
- Emergency equipment use/ emergency procedures
- Standard operating procedures
- General chemical handling guidelines
- Use of reference materials, including the chemical hygiene plan and SDSs
- Use of engineering controls as a barrier to chemical exposure (e.g. fume hoods)
- Signs and symptoms associated with hazardous chemical exposure
- Waste management and disposal

** Note: Respirators use (in lieu of engineering controls) requires additional training per 29 CFR 1910.134(c)(2)].**

18.1 REFERENCE MATERIALS

1. Reference materials on chemicals- hazards and safe handling methods include original container labels and SDSs. Faculty may also be a resource for reference materials.

2. Reference on laboratory safety- *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*, National Research Council, National Academy of Sciences, 2011, National Academies Press (ISBN-13: 978-0-309-13864-2). This should be considered an authoritative reference for laboratory practices.

3. Contact the Environmental Management Department for reference materials related to hazardous waste management and disposal.

Appendix A: OSHA Laboratory Standard

29 CFR 1910.1450—Occupational Exposure to Hazardous Chemicals in Laboratories

a. Scope and application.

1. This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.
2. Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

   i. For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.
   ii. Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.
   iii. Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.

3. This section shall not apply to:

   i. Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.
   ii. Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

      A. Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and
      B. Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

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

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee. "Carcinogen" (see "select carcinogen").

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

"Chemical Hygiene Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section. "Combustible liquid" means any liquid having a flashpoint at or above 100 deg. F (37.8 deg. C), but below 200 deg. F (93.3 deg. C), except any mixture having components with flashpoints of 200 deg. F (93.3 deg. C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

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

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

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

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

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

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

i. "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;
ii. "Gas, flammable" means: (A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or (B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
iii. "Liquid, flammable" means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. C) or higher, the total of which makes 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 have 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 chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

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

i. It is regulated by OSHA as a carcinogen; or
ii. It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or
iii. It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or
iv. It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria: (A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3); (B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or (C) After oral dosages of less than 50 mg/kg of body weight per day.

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

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

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

d. Employee exposure determination

1. Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).
2. Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.
3. Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.
4. Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

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

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

   i. Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and
   ii. Capable of keeping exposures below the limits specified in paragraph (c) of this section.

2. The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.
3. The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:

   i. Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;
   ii. Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;
   iii. A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;
   iv. Provisions for employee information and training as prescribed in paragraph (f) of this section;
   v. The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

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

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

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

A. Establishment of a designated area;
B. Use of containment devices such as fume hoods or glove boxes;
C. Procedures for safe removal of contaminated waste; and
D. Decontamination procedures.

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

f. Employee information and training.

1. The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.
2. Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.
3. Information. Employees shall be informed of:

i. The contents of this standard and its appendices which shall be made available to employees;
ii. the location and availability of the employer's Chemical Hygiene Plan;
iii. The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
iv. Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and
v. The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.

4. Training.

i. Employee training shall include:

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

g. Medical consultation and medical examinations.

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

   i. Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
   ii. Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
   iii. Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

2. All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.
3. Information provided to the physician. The employer shall provide the following information to the physician:

   i. The identity of the hazardous chemical(s) to which the employee may have been exposed;
   ii. A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
   iii. A description of the signs and symptoms of exposure that the employee is experiencing, if any.

4. Physician's written opinion.

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

      A. Any recommendation for further medical follow-up;
      B. The results of the medical examination and any associated tests;
      C. Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace; and
      D. A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

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

h. Hazard identification.

1. With respect to labels and material safety data sheets:

i. Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
ii. Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

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

i. If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.
ii. If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.
iii. If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.120) including the requirements for preparation of material safety data sheets and labeling.

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

j. Record-keeping.

1. The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.
2. The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

k. Dates.

1. Effective date. This section shall become effective May 1, 1990.
2. Start-up dates.

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

1. 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

Appendix A to 1910.1450 – National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (non-mandatory)

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Foreword

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene Plan, the following non-mandatory recommendations are provided. They were extracted form "Prudent Practices" for Handling Hazardous Chemicals in Laboratories" (referred to below as "Prudent Practices"), which was published in 1981 by the National Research Council and is available from the National Academy Press, 2101 Constitution Ave., NW,. Washington DC 20418.

"Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This Appendix merely presents pertinent recommendations from "Prudent Practices", organized into a form convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene Plan. Users of this appendix should consult "Prudent Practices" for a more extended presentation and justification for each recommendation.

"Prudent Practices" deal with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical Hygiene" being substituted for the word "safety". However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F.

The recommendations from "Prudent Practices" have been paraphrased, combined, or otherwise reorganized, and headings have been added. However, their sense has not been changed.

Corresponding Sections of the Standard and this Appendix

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph and topic in laboratory standard appendix section	Relevant
(e)(3)(i) Standard operating procedures for handling toxic chemicals.	C, D, E
(e)(3)(ii) Criteria to be used for implementation of measures to reduce exposures.	D

(e)(3)(iii) Fume hood performance	C4b
(e)(3)(iv) Employee information and training (including emergency procedures).	D10, D9
(e)(3)(v) Requirements for prior approval of laboratory activities.	E2b, E4b
(e)(3)(vi) Medical consultation and medical examinations.	D5, E4f
(e)(3)(vii) Chemical hygiene responsibilities.	B
(e)(3)(viii) Special precautions for work with particularly hazardous substances.	E2, E3, E4

In this appendix, those recommendations directed primarily at administrators and supervisors are given in sections A-D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (Reference to page numbers in "Prudent Practices" are given in parentheses.)

A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B-E, "Prudent Practices" expresses certain general principles, including the following:

1. It is prudent to minimize all chemical exposures. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2,10). Skin contact with chemicals should be avoided as a cardinal rule (198).
2. Avoid underestimation of risk. Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10, 37, 38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).
3. Provide adequate ventilation. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).
4. Institute a chemical hygiene program. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6,11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).
5. Observe the PELs, TLVs. The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded (13).

B. Chemical Hygiene Responsibilities

Responsibility for chemical hygiene rests at all levels (6, 11, 21) including the:

1. Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).
2. Supervisor of the department or other administrative unit, who is responsible for chemical hygiene in that unit (7).
3. chemical hygiene officer(s), whose appointment is essential (7) and who must:
    a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);
    b) Monitor procurement, use, and disposal of chemicals used in the lab (8);
    c) See that appropriate audits are maintained (8);
    d) Help project directors develop precautions and adequate facilities (10);
    e) Know the current legal requirements concerning regulated substances (50); and
    f) Seek ways to improve the chemical hygiene program (8, 11).
4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:
    a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);
    b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);
    c) Know the current legal requirements concerning regulated substances (50, 231);
    d) Determine the required levels of protective apparel and equipment (156, 160, 162); and
    e) Ensure that facilities and training for use of any material being ordered are adequate (215).
5. Project director or director of other specific operation, who has primary responsibility for chemical hygiene procedures for that operation (7).
6. Laboratory worker, who is responsible for:
    a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7, 21, 22, 230); and
    b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

1. Design. The laboratory facility should have:
    a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);
    b) Adequate, well-ventilated stockrooms/storerooms (218, 219).
    c) Laboratory hoods and sinks (12, 162);
    d) Other safety equipment including eyewash fountains and drench showers (162, 169); and
    e) Arrangements for waste disposal (12, 240).
2. Maintenance. Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continual appraisal and be modified if inadequate (11, 12).
3. Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).
4. Ventilation - (a) General laboratory ventilation. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).

a) (b) Hoods. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.
b) (c) Other local ventilation devices. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).
c) (d) Special ventilation areas. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).
d) (e) Modifications. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).
e) (f) Performance. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).
f) (g) Quality. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfm) (200, 204).
g) (h) Evaluation. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made (12, 195, 207). See pp 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures (Recommendations for these are given in section E, below)
2. Chemical Procurement, Distribution, and Storage
    a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).
    b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19).
    c) Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).
    d) Distribution. When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).
    e) Laboratory storage. Amounts permitted should be as small as practical. Storage on bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225-6, 229).

3. Environmental Monitoring

Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a highly toxic substance is stored or used regularly (e.g., 3 times/week) (13).

4. Housekeeping, Maintenance, and Inspections
    a) Cleaning. Floors should be cleaned regularly (24).
    b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).
    c) Maintenance. Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Other safety equipment should be inspected regularly. (e.g., every 3-6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).
    d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).

5. Medical Program
    a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).
    b) Routine surveillance. Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).
    c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment

These should include for each laboratory:

    a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);
    b) An easily accessible drench-type safety shower (162, 169);
    c) An eyewash fountain (162)
    d) A fire extinguisher (162-164);
    e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and
    f) Other items designated by the laboratory supervisor (156, 160).

7. Records
    a) Accident records should be written and retained (174).
    b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).
    c) Inventory and usage records for high-risk substances should be kept as specified in sections E3e below.

d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

8. Signs and Labels

Prominent signs and labels of the following types should be posted:

a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28);
b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);
c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumption and storage are permitted (24); and
d) Warnings at areas or equipment where special or unusual hazards exist (27).

9. Spills and Accidents
   a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).
   b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).
   c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).
   d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).

10. Information and Training Program
    a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5, 15).
    b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154, 169).
    c) Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6).
    d) Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.
    e) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).
    f) Frequency of Training: The training and education program should be a regular, continuing activity - not simply an annual presentation (15).
    g) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).

11. Waste Disposal Program.
    a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).
    b) Content (14, 232, 233, 240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials

can be incinerated. Transport from the institution must be in accordance with DOT regulations (244).

c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27).
d) Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).
e) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).
f) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241).

Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14).

Hoods should not be used as a means of disposal for volatile chemicals (40, 200).

Disposal by recycling (233, 243) or chemical decontamination (40, 230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals

The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the sub programs mentioned above, these should include the rules listed below.

1. General Rules

The following should be used for essentially all laboratory work with chemicals:

(a) Accidents and spills - Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention (33, 172).

Ingestion: This is one route of entry for which treatment depends on the type and amount of chemical involved. Seek medical attention immediately.

Skin Contact: Promptly flush the affected area with water (33, 172, 178) and remove any contaminated clothing (172, 178). If symptoms persist after washing, seek medical attention (33).

Clean-up. Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24, 33). See pp. 233-237 for specific clean-up recommendations.

(b) Avoidance of "routine" exposure: Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23);

Do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199).

Inspect gloves (157) and test glove boxes (208) before use.

Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

(c) Choice of chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate (13).

(d) Eating, smoking, etc.: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24).

Avoid storage, handling, or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).

(e) Equipment and glassware: Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23, 26).

(f) Exiting: Wash areas of exposed skin well before leaving the laboratory (23).

(g) Horseplay: Avoid practical jokes or other behavior which might confuse, startle or distract another worker (23).

(h) Mouth suction: Do not use mouth suction for pipeting or starting a siphon (23, 32).

(i) Personal apparel: Confine long hair and loose clothing (23, 158). Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes, or sneakers (158).

(j) Personal housekeeping: Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).

(k) Personal protection: Assure that appropriate eye protection (154-156) is worn by all persons, including visitors, where chemicals are stored or handled (22, 23, 33, 154).

Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect the gloves before each use, wash them before removal, and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given p. 159).

Use appropriate (164-168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164-5), inspecting the respirator before use (169).

Use any other protective and emergency apparel and equipment as appropriate (22, 157-162).

Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155).

Remove laboratory coats immediately on significant contamination (161).

(l) Planning: Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22, 23).

(m) Unattended operations: Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27, 128).

(n) Use of hood: Use the hood for operations which might result in release of toxic chemical vapors or dust (198-9).

As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13).

Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200).

Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).

(o) Vigilance: Be alert to unsafe conditions and see that they are corrected when detected (22).

(p) Waste disposal: Assure that the plan for each laboratory operation includes plans and training for waste disposal (230).

Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22, 24).

Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (231); or any substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).

(q) Working alone: Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).

2. Working with Allergens and Embryotoxins

(a) Allergens (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).

(b) Embryotoxins (34-5) (examples: organomercurials, lead compounds, formamide): If you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel (especially gloves) to prevent skin contact.

Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.

Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.

Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

3. Work with Chemicals of Moderate Chronic or High Acute Toxicity

Examples: diisopropylfluorophosphate (41), hydrofluoric acid (43), hydrogen cyanide (45).

Supplemental rules to be followed in addition to those mentioned above (Procedure B of "Prudent Practices", pp. 39-41):

(a) Aim: To minimize exposure to these toxic substances by any route using all reasonable precautions (39).

(b) Applicability: These precautions are appropriate for substances with moderate chronic or high acute toxicity used in significant quantities (39).

(c) Location: Use and store these substances only in areas of restricted access with special warning signs (40, 229).

Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 60 linear feet per minute) (40) or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance (39); trap released vapors to revent their discharge with the hood exhaust (40).

(d) Personal protection: Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

(e) Records: Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved (40, 229).

(f) Prevention of spills and accidents: Be prepared for accidents and spills (41).

Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity (39).

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40).

If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

(g) Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40).

Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

(Examples: dimethylmercury and nickel carbonyl (48), benzo-a-pyrene (51), N-nitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38).)

Further supplemental rules to be followed, in addition to all these mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of "Prudent Practices" pp. 47-50).

(a) Access: Conduct all transfers and work with these substances in a "controlled area": a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

(b) Approvals: Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

(c) Non-contamination/Decontamination: Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area (49, 50).

Decontaminate the controlled area before normal work is resumed there (50).

(d) Exiting: On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

(e) Housekeeping: Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

(f) Medical surveillance: If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance (50).

(g) Records: Keep accurate records of the amounts of these substances stored (229) and used, the dates of use, and names of users (48).

(h) Signs and labels: Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and warning labels (48).

(i) Spills: Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available (233-4).

(j) Storage: Store containers of these chemicals only in a ventilated, limited access (48, 227, 229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48, 229).

(k) Glove boxes: For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap the exit gases or filter them through a HEPA filter and then release them into the hood (49).

(l) Waste: Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49, 50, 233).

5. Animal Work with Chemicals of High Chronic Toxicity

(a) Access: For large scale studies, special facilities with restricted access are preferable (*Chapter 10*).

(b) Administration of the toxic substance: When possible, administer the substance by injection or gavage instead of in the diet. If administration is in the diet, use a caging system under negative pressure or under laminar air flow directed toward HEPA filters.

(c) Aerosol suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood).

(d) Personal protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator).

(e) Waste disposal: Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products; otherwise, package the waste appropriately for burial in an EPA-approved site.

F. Safety Recommendations

The above recommendations from "Prudent Practices" do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications for chemical hygiene:

1. Corrosive agents: (35-6)
2. Electrically powered laboratory apparatus: (179-92)
3. Fires, explosions: (26, 57-74, 162-64, 174-5, 219-20, 226-7)
4. Low temperature procedures: (26, 88)
5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27, 75-101)

G. Safety Data Sheets

Select safety data sheets presented in the 1981 edition of "Prudent Practices" are listed in the original language of this Appendix A document; however, no specific data sheets are listed in the 2011 edition, so the original 1981 listing is not provided here. The 2011 Edition of "Prudent Practices" provides a discussion of Safety Data Sheets on pages 47-50.

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APPENDIX B: STANDARD PLAN TERMS & DEFINITIONS

Action Level A concentration designated in 29 CFR 1910.1450 for a specific substance, calculated as an 8-hour time-weighted average, which initiates certain required activities (Appendix D).

Chemical Hygiene Officer An employee who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan.

Chemical Hygiene Plan A written program developed and implemented which sets forth procedures, equipment, person protective equipment (PPE), and work practices that are capable of protecting employees from health hazards and physical hazards presented by hazardous chemicals used in the laboratory. This plan shall be reviewed annually. If applicable, necessary updates will be incorporated within the annual time frame.

Designated Area An area that may be used for work with select carcinogens, reproductive toxins or substances that 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.

Hazardous Chemical 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, and neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

Laboratory A facility where the laboratory use of hazardous chemicals may occur. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis.

Laboratory Employee An individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his/her assignments whether full-time or part-time employees.

Laboratory Scale 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 Use of Hazardous Chemicals Handling or use of such chemicals in which the following conditions are met:

1. Chemical manipulations are carried out on a laboratory scale.
2. Multiple chemical procedures or chemicals are used.
3. The procedures involved are not part of a production process nor in any way simulate a production process.
4. Protective laboratory practices and equipment are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

Reproductive Toxins: Chemicals that affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogens).

Select Carcinogen Any substance that meets *one* of the following criteria:

1. It is regulated by OSHA as a carcinogen.
2. It is listed under the category, *known to be carcinogens,* in the Annual Report on Carcinogens published by the latest edition of the National Toxicology Program.
3. It is listed under Group 1 (carcinogenic to humans) by the International Agency for Research on Cancer Monographs (IARC).
4. It is listed in either Group 2A or 2B by IARC or under the category, reasonably anticipated to be carcinogens by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
   a. After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m^3;
   b. After repeated skin application of less than 300 mg/kg of body weight per week;
   c. After oral dosages of less than 50 mg/kg of body weight per day.

APPENDIX C: INCOMPATIBLE CHEMICAL TABLES

TABLE 1—PARTIAL LISTING OF INCOMPATIBLE CHEMICALS (REACTIVE HAZARDS)

Acetic Acid	Chromic Acid, Nitric Acid, peroxides, and permanganates
Acetic Anhydride	Hydroxyl-containing compounds, Ethylene Glycol, Perchloric Acid
Acetone	Concentrated acids such as Nitric Acid and Sulfuric Acid
Acetylene	Chlorine, Bromine, Copper, Silver, Fluorine, Mercury
Alkali metals-Na,K,Li,Mg,Ca	Carbon Dioxide, chlorinated hydrocarbons
Ammonia (anhydrous)	Mercury, Chlorine, Calcium Hypochlorite, Iodine, Bromine, Hydrogen Fluoride
Aniline	Nitric Acid, Hydrogen Peroxide
Bromine	Ammonia, Acetylene, Butadiene, Butane, Sodium Carbide, Benzene, turpentine
Calcium Oxide	Water
Carbon, activated	Calcium Hypochloride, other oxidants
Chlorates	Ammonium salts, acids, metal powders, Sulfur, finely divided organics
Chromic Acid	Acetic Acid, Naphthalene, Camphor, Glycerol, turpentine, alcohols
Chlorine Dioxide	Ammonia, Methane, Phosphine, Hydrogen Sulfide
Copper	Acetylene, Hydrogen Peroxide
Fluorine	*Isolate from everything*
Hydrazine	Hydrogen Peroxide, Nitric Acid, any other oxidant
Hydrocarbons (e.g. Toluene)	Fluorine, Chlorine, Bromine, Chromic Acid, peroxides
Hydrocyanic Acid	Nitric Acid, alkalis
Hydrofluoric Acid	Ammonia, aqueous or anhydrous
Hydrogen Peroxide	Copper, Chromium, Iron, other metals or their salts, organic solvents
Hydrogen Sulfide	Fuming Nitric Acid, oxidizing gases
Iodine	Acetylene, Ammonia (anhydrous or aqueous)
Mercury	Acetylene, Ammonia
Nitric Acid	Acetic Acid, Acetone, Aniline, Chromic Acid, organic solvents, Hydrogen Sulfide
Nitroparrafins	Inorganic bases, amines
Oxalic Acid	Silver, Mercury
Oxygen	Oils, grease, Hydrogen, flammable liquids, solids, or gases
Perchloric Acid	Acetic Anhydride, Bismuth and alloys, paper, wood, grease, oils, alcohols
Peroxides, organic	Acids (organic and mineral), should store cold
Phosphorus, white	Air, Oxygen
Potassium Chlorate	Acids, (see chlorates)
Potassium Perchlorate	Acids, (see perchloric acid)
Potassium Permanganate	Glycerol, Ethylene Glycol, Benzaldehyde, Sulfuric Acid
Silver	Acetylene, Oxalic Acid, Tartaric Acid, Ammonium compounds
Sodium	(see alkali metals)
Sodium Nitrite	Ethanol, Methanol, Acetic Acid, Acetic Anhydride, Carbon Disulfide, Glycerol
Sulfuric Acid	Chlorates, perchlorates, permanganates

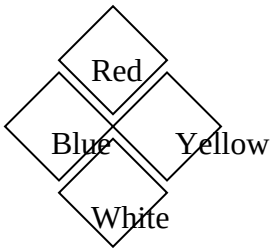
TABLE 2—PARTIAL LIST OF INCOMPATIBLE CHEMICALS (TOXIC HAZARDS)

Arsenical materials	Any reducing agent	Arsine
Azides	Acids	Hydrogen Azide
Cyanides	Acids	Hydrogen Cyanide
Hypochlorites	Acids	Chlorine
Nitrates	Sulfuric Acid	Nitrogen Dioxide
Nitric Acid	Copper, brass, heavy metals	Nitrogen Dioxide (nitrous fumes)
Nitrites	Acids	Nitrous fumes
Phosphorus	Caustic alkalis or reducing agents	Phosphine
Selenides	Reducing agents	Hydrogen Selenide
Sulfides	Acids	Hydrogen Sulfide
Tellurides	Reducing agents	Hydrogen Telluride

*****Tables reprinted from "Hazards in the Chemical Laboratory"*

Appendix D. National Fire Protection Association (NFPA) Hazard Diamond

This labeling system uses 4 diamonds of different colors to denote various types of hazards. Within each colored diamond is a number that indicates the level of hazard for the material.



Health (Blue Diamond)

0 *No health hazard when used with responsible care.*
1 *Slightly toxic material*. May cause irritation, but only minor residual injury even without treatment.
2 Moderately toxic material. Intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.
3 *Seriously toxic material*. Short term exposure could cause serious temporary or residual injury even though prompt medical treatment is given. Includes known or suspect small animal carcinogens, mutagens or teratogens.
4 *Highly toxic material*. Very limited exposure could cause death or major injury even though prompt medical treatment is given. Includes known or suspect human carcinogens, mutagens or teratogens.

Flammability (Red Diamond)

0 Materials which will not burn.
1 *Slightly combustible*. Material which requires considerable preheating before ignition can occur. This rating includes most ordinary combustible materials.
2 *Combustible*. Materials which must be moderately heated before ignition can occur. Includes liquids having a flash point above 100 degrees F, and solids which readily give off flammable vapors.
3 *Flammable*. Liquids and solids that can be ignited under almost all ambient temperature conditions. Includes liquids with a flash point below 73 degrees F and a boiling point above 100 degrees F, solid materials which form coarse dusts that burn rapidly without becoming explosive, materials which burn rapidly by reason of self-contained oxygen (i.e. organic peroxides), and materials which ignite spontaneously when exposed to air.

4 *Extremely flammable*. Materials which will rapidly vaporize at normal pressure and temperature and will burn readily. Includes gases, cryogenic materials, any liquid or gaseous material having a flash point below 73 degrees F and a boiling point below 100 degrees F, and materials which can form explosive mixtures with air.

Reactivity (Yellow Diamond)

0 Materials which are normally stable, even under fire conditions, and which are not reactive with water.
1 Materials which are normally stable, but which can become unstable at elevated temperatures and pressures, or which may react with water with some release of energy, but not violently.
2 Materials which in themselves are normally unstable and readily undergo violent chemical change, but do not detonate. It includes materials which may react violently with water or which may form potentially explosive mixtures with water.
3 Materials which in themselves are capable of detonation but which require a strong initiating source, or which must be heated first. This rating includes materials which are shock sensitive at elevated temperatures, and which react explosively with water without requiring heat.
4 Materials which in themselves are readily capable of detonation or explosive decomposition at normal temperatures and pressures. Includes materials which are shock sensitive at normal temperatures and pressures.

Special Notice (White Diamond)

OX Denotes materials that are oxidizing agents. These compounds give up oxygen easily, remove hydrogen from other compounds or attract negative electrons.

~~**W**~~ Denotes materials that are water reactive. These compounds undergo rapid energy releases on contact with water.