PART II

General Safety Practices

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1.0 PURPOSE

Part II of this Chemical Hygiene Plan is intended to provide Harvard University laboratory personnel with information regarding generic hazards of common chemicals that may be present in the laboratory and appropriate work practices, procedures and controls to protect laboratory workers from those hazards.

2.0 INTRODUCTION

Hazardous chemicals can cause harm when they enter the body in sufficient amounts via inhalation, ingestion, injection or skin absorption. Harmful effects can also occur by eye or skin contact alone. The nature of the hazardous chemical and the routes by which it enters or contacts the body determine the type of controls that are needed. The Occupational Safety and Health Administration (OSHA) and other organizations have set occupational exposure limits on airborne chemical exposure. Keeping exposures below these limits is generally believed to protect employees. Permissible Exposure Limits (PELs) set by OSHA can be found at http://www.osha-slc.gov/SLTC/pel/index.html. Threshold Limit Values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) are available on MSDSs or by contacting EH&S. Regardless of the established exposure limit for a particular chemical, all laboratory workers should take steps to minimize chemical exposure via all routes of entry.

Three methods are used to limit chemical exposure:

- Engineering controls;
- Administrative controls; and
- Personal protective equipment (PPE).

2.1 Engineering Controls

Whenever possible, substitution of less hazardous chemicals should be used as a primary method of preventing adverse effects due to chemical exposure.

Properly exhausted fume hoods, other local exhaust ventilation, glove boxes and other special purpose hoods must be used when there is a likelihood of excessive exposure to air contaminants generated by laboratory activity. Used in conjunction with good work practices, properly designed and operated exhaust ventilation is effective in minimizing air contaminant exposure.

2.2 Administrative Controls

- Administrative controls are work procedures such as safety policies, rules, supervision, and training in order to reduce the duration, frequency, and severity of exposure (via inhalation and physical contact) to hazardous chemicals. Some administrative controls include, but are not limited to, using granular materials

instead of powders, using low pours, avoiding working alone after hours with particularly hazardous substances or procedures, etc.

2.3 Personal Protective Equipment

The use of personal protective equipment (PPE) is necessary when feasible engineering and administrative controls are unavailable or if there is a need to supplement those controls. The following types of PPE are used to minimize inhalation and physical contact exposures:

- Eye and face protection: safety glasses, chemical splash goggles and faceshields.
- Protective clothing: lab coats, aprons, arm covers, and closed-toe shoes.
- Respiratory protection: respirators for short-term use or during emergencies may be necessary to supplement existing engineering or administrative controls.

3.0 PRIOR APPROVALS AND PROCUREMENT

Laboratory personnel should obtain prior approval to proceed with a laboratory procedure from a senior member of the lab staff or one more experienced in similar procedures when:

- Working with high hazard materials (see Appendix II-A for list);
- Performing high hazard procedures (i.e., potential for violent reaction); and/or
- Working alone with high hazard materials or hazardous procedures

The Chemical Hygiene Officer and/or Environmental Health and Safety are available to assist laboratory staff in reviewing hazards associated with any procedure, equipment or chemical to be used in the laboratory to ensure that appropriate safety procedures are established.

Part III of this Chemical Hygiene Plan is intended to provide guidance in the establishment and documentation of specific safety procedures.

4.0 GENERAL SAFETY PROCEDURES

4.1 Basic Precautions

Awareness is the most fundamental rule of chemical safety. Take time to understand the safety and health hazards of the chemicals in the workplace. Every laboratory worker should take the following precautions:

- Prior to use, review the safety and health hazard data of all chemicals used in the laboratory.
- Know the signs and symptoms of overexposure and the physical and sensory characteristics (odor, appearance) of these chemicals.

- Know appropriate procedures for emergencies, including the location and operation of all emergency equipment.
- When working with hazardous materials, have a second person nearby
- Avoid leaving experiments unattended, whenever possible.
- Never use unlabeled chemicals or chemicals.
- Always order the least amount of chemical.
- Use hazardous chemicals in a chemical fume hood
- Maintain equipment and inspect it regularly for proper function.
- Use guards and shields where possible. All mechanical equipment should have adequate guarding.
- Use safety shields when there is a possibility for explosion or implosion.
- Store and handle chemicals in accordance with the guidelines contained in this Chemical Hygiene Plan or in accordance with the chemical manufacturer's guidelines.
- Store hazardous waste in a closed, labeled container in a designated satellite accumulation area.
- Dispose of hazardous waste through the University Hazardous Waste Program (see http://www.uos.harvard.edu/ehs/env_pro_haz.shtml).
- Do not dispose of waste chemicals or hazardous wastes by pouring into sinks or drains (see http://www.uos.harvard.edu/ehs/enviro/Sink_Disposal.pdf).
- Do not eat, drink, chew gum, apply cosmetics while near or within chemical use or storage areas.
- Do not store food/drink containers in the laboratory or in a chemical refrigerator.
- Use mechanical pipettes or aspirators.
- Do not use chipped or cracked glassware.
- Report all accidents, even if they do not result in injury, to the principal investigator, chemical hygiene officer, laboratory supervisor and/or EH&S immediately.

4.2 Housekeeping/Hygiene

The following housekeeping and hygiene practices should be implemented at all times to reduce the likelihood of accident or chemical exposure:

- Work areas should be kept clean and free from obstructions.
- Hands should be washed after every experiment, before touching any non-contaminated area or object, and before leaving the laboratory area.
- Access to exits, emergency exits, aisles, hallways, stairways, stairwells and controls must never be blocked.
- Emergency exits must be kept unlocked from the inside.
- Hallways should not be used as storage areas.
- Work areas should be cleaned at the end of the experiment and at the end of the day.

4.3 Chemical Storage and Handling

Many potential hazards are associated with the storage and handling of laboratory chemicals. Understanding the properties of the chemicals and planning procedures by which they may be handled safely may minimize these hazards. Simply storing

chemicals alphabetically is not prudent. Flammable, corrosive, explosive, and peroxide forming agents require special precautions. Storing incompatible chemicals together may have disastrous results.

The following guidelines are prudent for all chemical storage and handling:

Chemical handling: Use bottle carriers to transport chemicals. Close caps securely. Pour all chemicals carefully. Add acid to water, not water to acid.

Labels: Be sure all labels are securely attached and legible. Keep chemicals in their original container if possible. Label all secondary containers to avoid unknown chemicals and/or inadvertent reaction. Date all chemicals which may become unstable over time or are peroxidizable.

Shelves: Avoid storing hazardous liquid chemicals on hard-to-reach shelves. Labels on stored chemicals should be able to be read easily. Shelves should be made of a chemically resistant material.

Incompatible chemicals: Incompatible chemicals must not be stored together. For each chemical, the hazardous nature must be considered individually and in relation to other chemicals in the area. Refer to the chemical MSDSs, waste compatibility links at https://www.uos.harvard.edu/ehs/env_pro_haz.shtml or see Appendix II-B for an alternative table of common incompatible chemicals.

Excessive storage: Avoid stockpiling chemicals. Purchase only what is needed. Use older stock first. Discard chemicals, which are no longer needed or that have expired.

Hallway storage: Hallways should not be used as storage areas for chemicals.

Chemical Fume hoods: In general, fume hoods should not be used for storage of chemicals, unless they are part of the experiment being conducted in the fume hood at that time. The exception is storage in a fume hood, which is specifically designed for that storage, and where experimental procedures are not carried out.

4.4 Flammable Liquids

Glass containers: Whenever practical, glass containers should not be used for storing flammable liquids. If a glass container must be used, the maximum allowable container size is one gallon.

Metal (non-DOT) or plastic containers: No more than 5 gallons of flammable liquid should be stored in regular metal or plastic containers.

Safety cans: Safety cans are the preferred containers for storage outside a flammable liquid storage cabinet. Safety cans are available in several sizes. They have spring-loaded spout covers that can open to relieve internal pressure when subjected to fire, and

will prevent leakage if tipped over. Flame arresters are present in the spout to prevent flame propagation into the can. The maximum size of the container should be 5 gallons.

Flammable liquid storage cabinets: Use of flammable liquid storage cabinets is the method of choice for storage of small quantities of flammable liquids. Flammable storage cabinets are made of double-walled steel, and are equipped with flame arresters. Some models have doors that close automatically and some have sprinkler systems. The cabinet must bear a label assuring that it is approved by Factory Mutual or Underwriters Laboratories.

Refrigerators/freezers: Refrigerators and freezers used for storage of flammable materials must be rated for flammable storage.

Maximum quantities: In general, no more than 10 gallons of flammable liquids per 100 square feet of laboratory space should be stored outside a flammable liquid storage cabinet or safety can.

Handling: Transfer and storage of flammable materials should not be in an area where a spill of the liquid could block an exit from the room, hallway, or building in the event of a fire, and where there is a source of ignition.

Incompatibles: Store flammable liquids separate from oxidizers, compressed gases, highly toxic materials, corrosives, and water-reactive chemicals.

4.5 Oxidizing Agents

Storage: Oxidizers should be stored on fire-resistant shelving, in a well-ventilated area.

Incompatibles: Oxidizing agents can initiate combustion and therefore should not be stored in the same area with fuel, such as flammable, organic chemicals, dehydrating agents, or reducing agents.

4.6 Perchloric Acid

At ordinary temperatures at concentrations of 72% and weaker, perchloric acid reacts as a strong, non-oxidizing acid. But at concentrations above 72% or at elevated temperatures (usually above 160 degrees Celsius), it is an exceedingly strong and active oxidizer and dehydrating agent. Anhydrous perchloric acid is unstable at room temperature and will ultimately decompose spontaneously with violent explosion.

Handling: Perchloric acid should be handled in a fume hood designed for perchloric acid use (must have a washdown system to prevent accumulation of crystals on the ductwork and the ductwork must be specially coated).

Incompatibles: Perchloric acid must be stored away from oxidizers and organic materials, including wood, paper, and cloth.

4.7 Peroxidizable Materials

Ethers, liquid parafins, and olefins form peroxides on exposure to air or light. Since these chemicals are packaged in an air atmosphere, peroxides can form even if the containers have not been opened (e.g. isopropyl ether, diethyl ether, dioxane, tetrahydrofuran, glyme, and diglyme). A list of common peroxidizable materials is contained in Appendix II-C.

Storage time limit: Opened containers should be used up or discarded within 6 months after they are first opened. Unopened containers should be stored no more than one year. Containers should be dated upon receipt and upon opening the bottle.

Container inspection: Containers should be inspected for peroxide formation before opening or moving the containers. If crystals are present around the lip of the container or the liquid appears cloudy, do not move or open it. Colorimetric tests are available to test for peroxide formation. Although some ethers contain a peroxide inhibitor, they should still be inspected before opening.

Dating of containers: To ensure storage time limits are not exceeded, containers of peroxidizable materials should be dated when received, when opened and when tested for peroxide formation. A sample dating label is contained in Appendix II-D.

4.8 Corrosive Materials

Corrosive substances are some of the most hazardous substances commonly encountered in the laboratory. In general, corrosive substances cause destruction of living tissue very rapidly at the site of contact (skin, eyes, respiratory tract and gastrointestinal tract). For this reason, proper selection and use of personal protective equipment is critical, when working with corrosives. See Section 6.0 for more specific guidance regarding personal protective equipment.

Containers: Whenever practical, corrosive materials should be purchased and stored in break-proof or break-resistant containers.

Storage: Many acids and alkalis are corrosive to their containers and other materials in a storage area. In general, they should be stored in a cool, dry area, equipped with corrosion-resistant shelving and plumbing, preferably in a corrosives storage cabinet.

Acids react with many metals to form hydrogen gas, and alkalis may form hydrogen gas when in contact with aluminum. Since hydrogen forms an explosive mixture with air, accumulation of hydrogen in storage areas must be prevented.

4.9 Toxic Materials

Toxic materials include carcinogens, reproductive toxins (teratogens, mutagens, etc.) and acutely hazardous materials. Toxic materials which are simultaneously hazardous because of another attribute (i.e. flammable, corrosive) should be evaluated to determine which is the most significant hazard and stored accordingly.

Access to these materials should be restricted to the people involved in the experiment and people who have been informed of the hazardous properties of the chemical. These chemicals should not be stored in a hallway, stairway, or any other emergency egress path regardless of whether they are contained in a storage can or cabinet. Additional precautions for working with toxic materials are contained in Section 5.0 of Part II of this Chemical Hygiene Plan. Lists of carcinogens are contained in Appendix II-A.

If the toxicity of the chemical is the primary hazard, the chemical should be stored in one of the following ways:

- In a continuously operating chemical storage fume hood;
- In a volatile storage cabinet with restricted access, such as a locked cabinet;
- In a hermetically sealed container at a temperature low enough to significantly reduce its volatility (i.e. a deep freeze).

4.10 Compressed Gas Cylinders

Compressed gas cylinders present an important hazard because they have the potential for both mechanical and chemical hazards. The danger of fire or explosion is acute with a high rate of diffusion. Additional hazards arise from the reactivity and toxicity of the gas. Asphyxiation can be caused by high concentrations of even "harmless" gases such as nitrogen. Finally, the large amount of potential energy resulting from the compression of the gas makes a compressed gas cylinder a potential rocket.

Identification: The contents of the cylinder should be clearly marked. Gas lines from the cylinder should be labeled as to the gas and the laboratory served. A tag should be attached to the cylinder to indicate whether the cylinder is full, in use, or empty.

Handling: During transport cylinders should be secured to appropriate handcarts. Highly toxic gases should not be moved through corridors in areas, where occupants not knowledgable in the hazards of the gases may be present. Cylinder valves should be opened slowly, using a hand wheel or wrench while standing upwind of the valve. Compressed Gas Association (CGA) approved valves, fittings and other connections of the proper configuration for the gas being used, should be employed at all times.

Storage: All cylinders, regardless of whether they are full or empty, must be firmly secured at all times, using a clamp and belt or chain. They should be stored in a cool, dry, well-ventilated area free from sources of ignition. Chemical oxidizers should be

stored at least 20 feet away from flammable gas cylinders. A cylinder cap or regulator valve should always be in place.

Empty cylinders: Cylinder caps should always be secured and cylinders should be clearly marked "empty". Empty cylinders should be kept secured as noted above.

5.0 HIGH HAZARD SAFETY PROCEDURES

Additional protection is required for work with particularly hazardous substances such as carcinogens, reproductive toxins (mutagens and teratogens), biotoxins and substances with a high degree of acute toxicity**.** Listings of these materials are contained in Appendix II-A. When working with these high hazard materials the following general procedures must be followed:

- Obtain approval from the principal investigator or his or her designee (i.e., senior member of the lab staff, lab supervisor, and/or chemical hygiene officer) to use these high hazard chemicals.
- Order the smallest quantity of the chemical necessary to perform the procedure or experiment.
- Wear appropriate personal protective equipment, paying close attention to permeation resistance of gloves or protective clothing to be used.
- Work only in a properly functioning, uncluttered chemical fume hood or biological safety cabinet. This area should be posted or labeled as a "Designated Area" for the use of high hazard materials. Permit only authorized personnel to use any Designated Area.
- Determine, in consultation with the the principal investigator or his or her designee (i.e., senior member of the lab staff, lab supervisor and/or chemical hygiene officer) and EH&S whether fume hood exhaust air should be filtered prior to discharge.
- Consult the MSDS for exposure and emergency information before beginning work with these materials.
- Label ALL containers with the contents, date, manufacturer's name and hazardous properties of the material(s) in the containers.
- Transfer high hazard chemicals in tightly closed containers placed within a durable outer container.
- Limit traffic through the immediate area.
- Decontaminate the work surface immediately after working with these materials. To facilitate decontamination, work surfaces may be covered with stainless steel or plastic trays, absorbent paper with moisture-proof lining or other impervious material, which may be cleaned or disposed of as hazardous waste or biological waste after completing the procedure.
- Securely store these materials immediately after use.
- Label all waste materials with the corresponding chemical classification (e.g. Toxic) or as biological waste.

Laboratories that use high hazard chemicals should document specific standard operating procedures for these materials and include them in Part III of this Chemical Hygiene Plan. Additional information about carcinogens, reproductive toxins, biotoxins and acutely toxic substances is contained in Appendix II-A.

6.0 PERSONAL PROTECTIVE EQUIPMENT

The use of personal protective equipment is necessary when feasible engineering and administrative controls are unavailable or if there is a need to supplement those controls. Requirements for the use of PPE are as follows:

6.1 Body and Foot Protection

When working with chemicals, a lab coat or apron and closed-toe shoes should be worn at all times. Hair and loose clothing should be confined.

6.2 Hand Protection

Hands are the most likely part of the body to come in contact with chemicals. Skin contact with chemicals may result in irritation, burns, or absorption of the chemical into the blood stream. Glove materials must be compatible with the chemical(s) used. Consult the MSDS for the chemical, the glove manufacturer's literature or EH&S for chemical protective clothing references when choosing gloves for a specific application.

6.3 Eye Protection

Safety glasses, goggles, or face shields should always be worn when eye hazards are possible. Students and visitors should be provided with eye protection before entering a laboratory.

- **Safety glasses** must be used when working with solid materials. Safety glasses should comply with the ANSI Occupational and Educational Eye and Face Protection Standard (Z87.1). Standard eyeglasses with side shields are generally not sufficient. Safety glasses should not be used when a significant splash potential exists.
- **Chemical Splash Goggles** must be used when a splash hazard exists. These generally can be worn over regular eyeglasses. Goggles equipped with vents should be used to prevent fogging.
- **Face shields** must be worn when maximum protection from flying particles and harmful liquids is needed. These may be used in conjunction with goggles for maximum protection from corrosives and hot chemicals.

6.4 Respirators

When chemical substitution and effective engineering controls are not possible, respirators should be used. The OSHA Respirator Standard 29 CFR 1910.134 must be complied with for all personnel who are required or volunteer to wear a respirator. This standard specifies medical surveillance, training, fit testing, selection, and guidelines for proper use. EH&S must be contacted before purchasing or using respiratory protection.

Environmental Health and Safety offers training and fit testing services for those workers who may require respirators. In addition EH&S is available to assist laboratories in establishing an OSHA-compliant Respirator Program.

7.0 OTHER SAFETY EQUIPMENT

7.1 Fume Hoods/Ventilation

The laboratory fume hood is one of the most important safety devices in the laboratory.

Use: The ventilation system in the laboratory has been carefully balanced to ensure proper airflow and comfortable working conditions. To prevent crossdrafts, laboratory doors should be kept closed, whenever possible. A complete guide to proper use of a laboratory fume hood is contained in Appendix II-E.

Maintenance: Laboratory fume hoods are evaluated by Environmental, Health and Safety or outside contractors at least annually. During these evaluations, average face velocity of the hood is measured, and the hood air flow characteristics and turbulence (if any) is visually evaluated.

Hoods passing evaluation are labeled at a 14" sash height with a fume hood inspection sticker indicating the date of evaluation. Hoods failing evaluation are posted with a failure notification form, and the hood operator(s) is informed of the failure. Failed hoods are reported to Building Managers for service and are reevaluated after service has been completed.

7.2 Eyewash Stations

Eyewash stations are required in any lab where there is the potential for eye injury from exposure to hazardous chemicals.

Requirements: The eyewash station must be capable of providing a continuous, soft stream of tepid water for at least 15 minutes. Personal eyewash units composed of bottled solution are generally not acceptable. Drench hoses may support eyewash stations, but do not replace them.

Location: Eyewash stations should be located within 100 feet, and should require no more than 10 seconds travel time from the hazard. The location should be marked with a highly visible sign.

Maintenance: Eyewash stations should be flushed weekly for 1 minute to assure function and avoid build-up of bacteria. The path to the eyewash station must be free from obstructions.

Use: After any eye contact with a chemical, activate the eyewash station and flush eyes for at least 15 minutes. If the chemical is alkaline, flush for at least 30 minutes. Avoid

rinsing the chemical into the uninjured eye. If contact lenses are in place, flush for one minute, remove the lenses, and continue flushing. After flushing for the appropriate amount of time, seek medical attention at the University Health Services or the nearest emergency room.

7.3 Safety Showers

Safety showers should be provided where chemicals are handled. The showers provide first aid for chemical splashes.

Requirements: Safety showers should provide at least 30 gallons of water per minute. The valve should be simple to activate and should remain activated until intentionally shut off. The valve should be within reach, not more than 69 inches above the floor.

Location: Safety showers should be in an accessible location no more than 10 seconds travel time or 100 feet from the hazard. The location should be marked with a clearly visible sign and, if possible, a large yellow circle should be painted on the floor under the shower.

Maintenance: Safety showers should be flushed at least annually, preferably every six months. The path to the safety shower must be kept free from obstructions.

Use: In case of skin contact with a hazardous chemical, immediately activate the shower and flush the affected area for at least 15 minutes. If the chemical is alkaline, flush for at least 30 minutes. For contact with dry solids, brush the contaminant gently off the skin before using the shower. While under the shower, remove clothing and jewelry from the affected area. After flushing, seek medical attention immediately at the University Health Services or the nearest emergency room.

7.4 Fire Extinguishers

Portable fire extinguishers are necessary for the rapid suppression of small fires. Only people trained in the use of a fire extinguisher should operate one. Never try to fight a fire that is larger than you are.

Types of fires: There are four types of fires, depending on the material that is burning:

- Class A Fires: Fires in ordinary combustible materials, such as wood, cloth, paper, and many plastics.
- Class B Fires: Fires involving flammable liquids, gases, and greases.
- Class C Fires: Fires in energized electrical equipment. When the electrical equipment is de-energized, the fire may continue to burn as a Class A or B fire.
- Class D Fires: Fires in combustible metals, such as magnesium, titanium, sodium, zirconium, and potassium.

Types of extinguishers: There are several types of fire extinguishers. An extinguisher is rated as to the type of fire it can put out. The type of fire the extinguisher is designed to extinguish is printed on the cylinder. A triangle with an "A" denotes Class A, a square with a "B" denotes Class B, a circle with a "C" denotes Class C, and a star with a "D" denotes Class D.

Location: Fire extinguishers are generally mounted either near an exit or at the back of the laboratory. There should be at least one extinguisher in each laboratory.

Maintenance: All extinguishers must be inspected annually. An inspection tag must be attached to each extinguisher and must indicate the date of the last inspection.

Use: Before using a fire extinguisher, SOUND THE ALARM or call 5-5560 (Cambridge/Allston) or 2-1720 (Longwood) to report the fire. If the fire is small and you are trained to use a fire extinguisher, choose the correct fire extinguisher by checking the label. Point the nozzle at the base of the flame with a side-to-side motion. If the fire becomes larger than you, or the contents of the extinguisher have been discharged and the fire is still burning, evacuate the building closing doors behind you (but do not lock them).

8.0 CHEMICAL WASTE MANAGEMENT

This section outlines the key elements of the Harvard University Laboratory Hazardous Waste Program. Additional information is available by contacting your campus EH&S office or the EH&S web site at:

http://www.uos.harvard.edu/ehs/env_pro_haz.shtml

8.1 Waste Identification

Hazardous waste regulations require that hazardous waste be accurately identified. Common laboratory wastes include:

- **Spent solvents, acids, bases and oxidizers** used in extractions, cleaning or other processes;
- **Unused reagents and other chemicals** that are no longer needed, do not meet specifications, are contaminated, have exceeded their storage life or are otherwise unusable in the lab;
- **Waste oils**; and
- **Other miscellaneous materials**, including broken thermometers, heavy metal salts, poisons, etc.

These wastes may be identified as either "listed wastes" (appear on lists of specific chemicals defined as hazardous waste issued by the Massachusetts Department of Environmental Protection (DEP)) or "characteristic wastes" (exhibit certain characteristics defined by the DEP including ignitability, corrosivity, reactivity and

toxicity). Environmental, Health and Safety is available to assist with waste identification.

8.2 Storage and Disposal

Regulations require that hazardous wastes be accumulated and stored in properly managed containers on sufficiently impervious surfaces (free of cracks, gaps, etc.).

Storage: Hazardous waste in laboratories is stored in satellite accumulation areas.

Disposal: Once a satellite accumulation area container is filled, it must be dated and transferred to a main accumulation area or shipped off-site within 3 days. Environmental, Health and Safety is available to provide waste pick up services. ***Disposal of hazardous wastes and chemicals in laboratory sinks is prohibited by regulation.***

Labeling: Containers that accumulate and store hazardous waste must be labeled with the following information:

- The words "Hazardous Waste";
- The waste type in words (Spent non-halogenated Solvents, Waste Oil etc.);
- The associated hazard in words (i.e. ignitable, toxic, etc.); and
- The date upon which the container became filled.

Containers must be labeled and situated so that labels are clearly visible.

Closure: Containers must be closed at all times, unless waste is being added or removed. Open-top funnels may not be left in open containers.

Condition: Containers must be in good condition. There may not be severe rusting, dents or other conditions that could cause leaks, etc.

Compatibility: Containers must be compatible with hazardous waste stored within them. When in doubt, use the original shipping container.

Inspections: Containers must be inspected weekly by laboratory personnel to ensure that they are properly labeled, in good condition and meet the criteria described above.

8.3 Training

Laboratory personnel whose duties or activities involve the management of hazardous waste are required to receive hazardous waste training within 6 months of the start of such activities and annually thereafter. Initial and refresher training is offered by Environmental, Health and Safety. Classroom training schedules and online refresher training is available at the EH&S web site at:

http://www.uos.harvard.edu/ehsapps/training/training.jsp

8.4 Waste Minimization

Federal law requires generators of hazardous waste to implement measures to limit and reduce the volume and toxicity of hazardous waste. Laboratory waste minimization techniques include:

- Process/equipment adjustment or modification;
- Toxic material substitution;
- Waste segregation and separation; and
- Recycling

The exercise of prudence in ordering new chemicals will also ensure that excess chemical does not become subject to disposal has hazardous waste. Contact Environmental Health and Safety for more information regarding waste minimization. The Environmental Protection Agency (EPA) has excellent resource materials to assist with waste minimization. You may access the EPA Home Page at the following address:

http://www.epa.gov/p2/

9.0 EMERGENCY PROCEDURES

Campus-specific Emergency Response (ER) Guides are available on flip charts posted around campus buildings and at the EH&S website at:

http://www.uos.harvard.edu/ehs/lp_emerg.shtml

These ER Guides include emergency contact numbers and procedures to implement during situations that include medical emergencies, fires, and hazardous material spills.

Appendix II-A

High Hazard Chemical Information

HIGH HAZARD CHEMICAL INFORMATION

SELECT CARCINOGENS

Select carcinogens are substances that meet any of the following criteria:

1. Regulated by OSHA as a carcinogen. Detailed information about OSHA standards and guidance on regulated carcinogens can be found at:

http://www.osha-slc.gov/SLTC/carcinogens/index.html

2. Listed under the category "known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicological Program (NTP). The latest edition (Tenth Edition published in December 2002) of the NTP Report on Carcinogens can be found at:

http://ehp.niehs.nih.gov/roc/toc10.html

Specifically, the current NTP listing of known human carcinogens can be found at:

http://ehp.niehs.nih.gov/roc/tenth/known.pdf

3. Listed under Group 1 ("Carcinogenic to humans") by the International Agency for Research on Cancer (IARC) Monographs. IARC Monographs can be found at:

http://www-cie.iarc.fr/monoeval/grlist.html

The current IARC Group 1 carcinogen listing can be found at:

http://www-cie.iarc.fr/monoeval/crthgr01.html

4. Listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by the NTP, and cause statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

- Inhalation exposure of 6-7 hr/day, 5 days/wk, for significant portion of a lifetime to airborne concentrations of less than 10 milligrams per cubic meter of air (mg/m^3); or
- Repeated skin application of less than 300 mg/kg body weight per week; or
- Oral doses less than 50 mg/kg body weight per day.

The current IARC Group 2A and Group 2B carcinogen listings can be found at:

Group 2A http://www-cie.iarc.fr/monoeval/crthgr02a.html
Group 2B http://www-cie.iarc.fr/monoeval/crthgr02b.html

The current NTP listing of reasonably anticipated human carcinogens can be found at:

http://ehp.niehs.nih.gov/roc/tenth/reason.pdf

REPRODUCTIVE TOXINS

Reproductive toxins are chemicals that adversely affect the reproductive process. These toxins include mutagens that can cause chromosomal damage and teratogens, the effects of which include retarded fetal growth, birth defects, fetal malformations, and fetal death.

Knowledge of how chemicals affect reproductive health is in its preliminary stage. It has been only since 1973 that manufacturers were required by the Toxic Substances Control Act (TSCA) to test chemicals other than drugs for their effects on reproductive health.

Although a few well-controlled studies have been conducted, the evidence for most chemicals is limited to case reports or to studies done on a small group of exposed people after a problem emerged. Of approximately 55,000 chemical substances and mixtures in commercial production (not including drugs, pesticides, and food additives), only a limited number have been tested thoroughly on animals for reproductive effects.

Sources of information about chemicals that pose a risk to human reproduction include:

- The chemical list generated pursuant to the State of California's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). This list, which includes chemicals known to the State of California to cause reproductive/developmental toxicity (and cancer), can be found in the download area at:

  http://www.oehha.ca.gov/prop65/prop65_list/Newlist.html

- Material Safety Data Sheets (MSDSs) for those chemicals.
- The Environmental Health and Safety Department.

ACUTELY TOXIC SUBSTANCES

Acutely toxic substances produce adverse effects when exposed individuals receive only small doses of that substance for a short period of time. (Hydrogen fluoride, for example.) Substances with a high degree of acute toxicity include, but are not limited to:

- Toxic and highly toxic gases; or
- All substances with a median oral lethal dose (LD_{50}) in rats of less than 50 mg/kg body weight.

Information concerning lethal doses and other measures of acute toxicity for particular substances is available on the MSDS for a particular substance, from the manufacturer or the Environmental Health and Safety Department.

The Department of Health and Human Services (DHHS) has identified a select group of biotoxins, which are considered particularly hazardous and acutely toxic. DHHS has enacted several rules that regulate the use and transfer of these agents. These agents are:

- Abrin
- Aflatoxins
- Botulism toxins
- *Clostridium perfringens* epsilon toxin
- Conotoxins
- Diacetoxyscirpenol
- Ricin
- Saxitoxin
- Shigatoxin
- Staphylococcal entertoxins
- Tetrodotoxin
- T-2 toxin

Please note that users or transporters of these agents must also register with the Centers for Disease Control and Prevention (CDC). Contact the EH&S Biosafety Manager for assistance if you use or transport any of these agents.

Appendix II-B

Chemical Incompatibility Information

CHEMICAL COMPATABILITY INFORMATION

Examples of incompatible chemicals are listed below. The material on the left should be stored and handled so that it does not contact the incompatible chemical(s) on the right. Contact with incompatible chemicals would result in a potential violent reaction or toxic reaction products.

Examples of Incompatible Chemicals

CHEMICAL	IS INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH	CHEMICAL	IS INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates	**Hydrogen peroxide**	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, combustible materials
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury	**Hydrogen sulfide**	Fuming nitric acid, oxidizing gases
Accetone	Concentrated nitric and sulfuric acid mixtures	**Hypochlorites**	Acids, activated carbon
Alkali and alkaline earth metals (such as powdered aluminum or magnesium, calcium, lithium, sodium, potassium)	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens	**Iodine**	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Ammonia (anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)	**Mercury**	Acetylene, fulminic acid, ammonia
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrates, sulfur, finely divided organic or combustible materials	**Nitrates**	Sulfuric acid
Aniline	Nitric acid, hydrogen peroxide	**Nitric Acid (concentrated)**	Acetic acid, aniline, chromic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Arsenical materials	Any reducing agent	**Nitrites**	Acids
Azides	Acids	**Nitroparaffins**	Inorganic bases, amines
Bromine	See Chlorine	**Oxalic acid**	Silver, mercury
Calcium Oxide	Water	**Oxygen**	Oils, grease, gydrogen, flammable liquids, solids, or gases
Carbon (activated)	Calcium hypochlorite, all oxidizing agents	**Perchloric acid**	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils
Carbon tetrachloride	Sodium	**Peroxide, organic**	Acids (organic or mineral), avoid friction, store cold
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials	**Phosphorus (white)**	Air, oxygen, alkalis, reducing agents
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, alcohol, flammable liquids in general	**Potassium**	Carbon tetrachloride, carbon dioxide, water
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine	**Potassium chlorate**	Sulfuric and other acids
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide	**Potassium perchlorate (see also chlorates)**	Sulfuric and other acids

Copper	Acetylene, hydrogen peroxide	**Potassium permanganate**	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Cumene hydroperoxide	Acids (organic or inorganic)	**Selenides**	Reducing agents
Cyanides	Acids	**Silver**	Acetylene, oxalic acid, tartartic acid, ammonium compounds, fulminic acid
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens	**Sodium**	Carbon tetrachloride, carbon dioxide, water
Fluorine	Everything	**Sodium nitrate**	Ammonium nitrate and other ammonium salts
Hydrocarbons (such as butane, propane, benzene)	Fluorine, chlorine, bromine, chronic acid, socium peroxide	**Sodium peroxide**	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydrite, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Hydrocyanic acid	Nitric acid, alkali	**Sulfides**	Acids
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)	**Sulfuric acid**	Potassium chlorate, potassium perchlorate, potassium permanaganate (similar compounds of light metals, such as sodium, lithium)
		Telurides	Reducing agents

Appendix II-C

List of Peroxidizable Materials

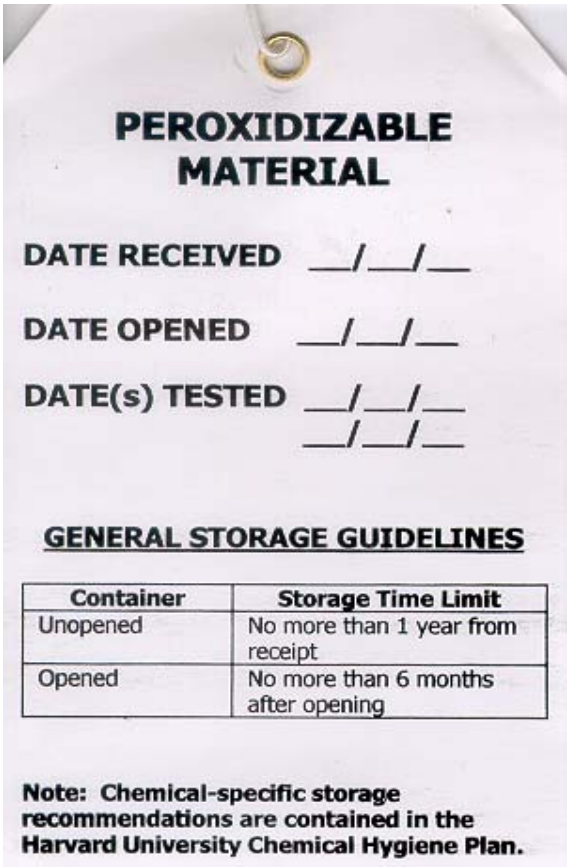
Classes of Chemicals That Can Form Peroxides Upon Aging

Class I	Class II	Class III
Recommended to discard or test for peroxides 6 months after first opened	Recommended to discard or test for peroxides 6 months after first opened	Recommended to discard within **3 months** after first opened
Unsaturated materials, especially those of low molecular weight, that may polymerize violently and hazardously due to peroxide initiation.	Chemicals which are a peroxide hazard upon concentration (distillation/ evaporation).	Peroxides derived from the following compounds may explode without concentration.
Acrylic acid	**Acetaldehyde diethyl acetal (acetal)**	**Diisopropyl ether (isopropyl ether)**
Acrylonitrile	**Cumene (isopropylbenzene)**	**Divinyl ether**
Butadiene	**Cyclohexene**	**Divinyl acetylene (DVA)**
Chlorobutadiene (chloroprene)	**Cyclooctene**	**Potassium metal**
Methyl methacrylate	**Cyclopentene**	**Potassium amide**
Styrene	**Decalin (decahydronaphthalene)**	**Sodium amide (sodamide)**
Tetrafluoroethylene (TFE)	**Diacetylene (butadiene)**	**Vinylidene chloride (1,1-dichloroethylene)**
Vinyl acetate	**Dicyclopentadiene**	
Vinyl acetylene (MVA)	**Diethyl ether (ether)**	
Vinyl chloride	**Diethylene glycol dimethyl ether (diglyme)**	
Vinyl pyridine	**Dioxane (*p*-dioxane)**	
	Ethylene glycol dimethyl ether (glyme)	
	Ethylene glycol ether acetates	
	Ethylene glycol monoethers (cellosolves)	
	Furan	
	Methyl acetylene	
	Methyl cyclopentane	
	Methyl-isobutyl ketone	
	Tetrahydrofuran (THF)	
	Tetralin (tetrahydronaphthalene)	
	Vinyl ethers	

Note: This table is not all inclusive.

Appendix II-D

Peroxidizable Material Label



PEROXIDIZABLE MATERIAL

DATE RECEIVED __/__/__

DATE OPENED __/__/__

DATE(s) TESTED __/__/__
__/__/__

GENERAL STORAGE GUIDELINES

Container	Storage Time Limit
Unopened	No more than 1 year from receipt
Opened	No more than 6 months after opening

Note: Chemical-specific storage recommendations are contained in the Harvard University Chemical Hygiene Plan.

Appendix II-E

Fume Hood Facts

FUME HOOD FACTS

Harvard's Department of Environmental Health and Safety (EH&S) provides annual fume hood inspection and evaluation. The following work practices for laboratory fume hoods are recommended to prevent exposure to hazardous materials.

Recommended Work Practices for Laboratory Fume Hoods

No large, open-face hood with a low face velocity can provide complete worker protection against all events that may occur in the hood. The hood may not adequately protect the worker from volatile or airborne contaminants with a low exposure limit (part per billion range). For more typical exposures, a well-designed hood in a properly ventilated room can provide adequate protection. However, certain work practices are necessary in order for the hood to perform adequately. The following work practices are generally required, however more stringent practices may be necessary in some circumstances.

1. Conduct all operations that may generate irritating and/or hazardous air contaminants inside a hood.
2. Keep all apparatus and chemicals at least 6 inches back from the face of the hood. A stripe on the bench surface inside the hood is a good reminder.
3. Do not lean into the hood or put your head in the hood when contaminants are being generated.
4. Do not use the hood as a waste disposal method (i.e. volatilize chemicals).
5. Do not store chemicals or apparatus in the hood. Store hazardous chemicals in an approved safety cabinet. Some hoods have acid or flammable storage cabinets below.
6. Keep the hood sash closed as much as possible. During use, position sash at or below the height indicated on hood evaluation label.
7. Keep the slots in the hood baffle free of obstruction by apparatus or containers.
8. Use equipment with legs or otherwise raise it off the work surface to allow even air flow under equipment, as well as around and over it.
9. Minimize sources of turbulence at the hood face (i.e. foot traffic, equipment, fans, moving arms in and out).
10. Keep laboratory doors closed, whenever possible.
11. Do not remove hood sash or panels except when necessary for apparatus set-up. Replace sash or panels before operating the hood.
12. Do not place electrical receptacles or other ignition sources inside the hood when flammable liquids or gases are present. No permanent electrical receptacles are permitted in the hood.
13. Use an appropriate barricade or shield, if there is a chance of explosion or eruption.

For further information concerning the use and/or performance of fume hoods contact Environmental Health and Safety at:

Longwood Campus 432-1720 **Cambridge/Allston Campus 495-2060**