

---

---

## IV. CHEMICAL HAZARDS

Working with toxic chemicals is an everyday occurrence in a laboratory. Hazardous situations can arise if employees are not educated in general chemical, safety and toxicological information, as well as information on the specific chemicals they are using. This section addresses some general information and some specific protocols to be practiced to minimize chemical hazards.

### A. General

#### 1. Useful Definitions

- a. Toxicity: the ability of a substance to produce an unwanted effect when the chemical has reached a sufficient concentration at a certain site in the body.
- b. Hazard: the probability that a such a concentration will occur (see toxicity definition above).
- c. Dose: the concentration of a substance and the time period during which the exposure occurs.
- d. Acute: a single exposure episode which occurs over a short time period.
- e. Chronic: a series of exposures occurring over a longer time period.
- f. Odor Threshold: the minimum concentration of a substance at which a majority of test subjects can detect and identify the characteristic odor of a substance.
- g. Threshold Limit Value (TLV): the time-weighted average airborne concentration established by the American Conference of Governmental Industrial Hygienists (ACGIH) for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effects.
- h. Permissible Exposure Limit (PEL): The maximum legal time-weighted average airborne exposure permitted during an eight-hour work day published and enforced by OSHA.

#### 2. Material Safety Data Sheets

Specific information regarding the hazards of the chemical or product being used may be found on that product's material safety data sheet (MSDS). Information that is contained in the MSDS is also required by law to be conveyed to employees either on a chemical-by-chemical basis or generically by chemical

---

---

classification. An MSDS is required to be readily available to the laboratory for every hazardous chemical used in the laboratory. For additional information regarding MSDSs, please refer to the *OU Hazard Communication Program*.

### 3. Modes of Entry

There are three major modes of entry for chemicals: inhalation, skin absorption, and ingestion. Inhalation and skin absorption are the predominant occupational exposures expected to be encountered in the laboratory and will be discussed in some detail. Accidental ingestion of chemicals can be eliminated by a combination of good laboratory and hygiene practices. The mode of entry for each chemical varies. Specific information for each chemical may be found on its MSDS.

Sources: American Conference of Governmental Industrial Hygienists, *2005 Threshold Limit Values for Chemical Substances and Physical Agents*  
National Safety Council, *Fundamentals of Industrial Hygiene, Third Edition*

## B. Organic Solvents

Organic solvents are perhaps the most ubiquitous chemicals found in the laboratory. Solvents are generally classified as either halogenated or non-halogenated. Non-halogenated solvents are often flammable, whereas halogenated solvents are, in general, non-flammable. However, halogenated solvents do decompose under fire conditions and high concentrations of toxic vapors, such as phosgene and hydrogen chloride, may be produced.

The potential chronic health effects of solvents warrant special attention since employees are more likely to be exposed to solvents than any other type of chemical. Chronic effects of solvent exposure vary widely, however, chronic exposures to solvents such as benzene, toluene, xylene, chloroform, carbon tetrachloride, and trichloroethylene have been associated with lung, liver and kidney damage.

The primary route of exposure to organic solvents is through inhalation of vapors. In general, high concentrations of the vapor, when inhaled, can produce drowsiness, dizziness and headaches. Most of the solvents will also act as upper respiratory tract irritants and the vapor may be an eye irritant. One physical property common to most solvents is that they have an odor, however, detection or lack of detection of a solvent odor offers little in the way of determining whether the environment is immediately hazardous. Solvent odor thresholds vary widely and acclimation is often rapid. Butyl mercaptan (or butyric acid) has an extremely disagreeable odor but is not particularly hazardous. Chloroform, however, has sweet odor to many people who may tolerate concentrations far in excess of what is safe.

Skin contact is also of concern with solvents. Solvents can act to defat the skin causing drying and cracking of the skin, which may lead to chronic dermatitis if exposure is prolonged and repeated. Some solvents such as amines, phenol and various cresols can also act as a corrosive when applied to the skin.

---

In addition, many of the solvents such as n-butyl alcohol, carbon disulfide, and phenol will penetrate the skin and be absorbed into the body. For those solvents where skin absorption is of concern, there will be a notation of skin exposure on the MSDS. Most skin contact with solvents can be avoided by wearing appropriate gloves. It is important that the glove be matched with the solvent since certain solvents will penetrate certain glove materials. Using the wrong glove can give a false sense of security and overexposure via the skin may result. If a solvent penetrates through the glove, it will have a prolonged contact with the skin because it is held against the skin and does not evaporate. Check with the glove manufacturer or check out the links on the EHSO web site for additional information regarding glove compatibility and use with solvents.

Direct liquid contact by solvents in the eyes can be very serious. Always wear appropriate eye protection when the potential for splash exists.

Whenever possible, use volatile solvents in a properly operating fume hood to eliminate inhalation hazards, use correct skin and eye protection, and use good laboratory and hygiene techniques to eliminate any possible exposure to volatile solvents.

### **C. Corrosives**

Corrosive materials include organic and inorganic acids and bases. Minor exposures are generally reversible, although often painful for a short period of time. The reversibility of the effects of exposure to corrosives will depend on the duration of exposure, concentration of the material, and the first aid methods used.

As with solvents, exposure can occur through inhalation or by skin absorption. If inhalation should occur, remove the victim from the area and try to keep the victim from breathing too deeply, as this will in many cases exacerbate the effects. Get the victim to medical assistance as soon as possible, as the lungs will begin to build up fluid to counteract the effects of the vapors.

Skin contact is the most common route of exposure. In concentrated forms, all types of corrosives will cause severe penetrating burns if not properly treated. However, skin contact with dilute solutions may not be rapidly detected, leading to longer exposure times and increased chance of injury.

Neoprene gloves provide the best protection from skin exposure to both acids and bases. When working with concentrated acids or bases, a laboratory coat or apron is also recommended, as well as a full face shield and chemical splash goggles when splash is possible.

If there is skin or eye contact with corrosives, make sure to flush the area with water for at least 15 minutes. Although 15 minutes seems like a long time period, it is necessary in order for the corrosive to be thoroughly washed off the skin or eye.

### **D. Toxic Solids**

The number of solid chemicals in the laboratory usually exceeds the total amount of

solvents, acids, and bases combined. In the solid form, the greatest risk of exposure is through inhalation of dust. This can be eliminated by thorough, careful work practices and/or working in a fume hood.

Skin absorption can be of concern when toxic solids are dissolved in a solution, particularly when an organic solvent is used which can penetrate the skin rapidly. Also, an oxidizing material dissolved in water can act directly on the skin to cause irritation that the solid alone would not cause.

#### E. Carcinogenic Material

1. OSHA requires the use of a "designated area" when working with "select carcinogens", defined as any substance which meeting one of the following criteria:
  - a. it is regulated by OSHA as a carcinogen; or
  - b. 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
  - c. it is listed under Group I ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or
  - d. it is listed in either the Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP.
2. The MSDS for each chemical or product should provide information regarding its chemical carcinogenicity/toxicity. A list of carcinogens and suspect carcinogens is available from the EHSO.
3. Laboratories working with carcinogenic material as defined above, should adhere to the following requirements.
  - a. Standard Operating Procedures (SOPs) should be prepared for the use of each chemical carcinogen/suspect carcinogen. These should be inserted into the *Laboratory Safety Manual* in Section XIX., "Standard Operating Procedures". All employees should be trained in these procedures and routinely follow them. Prior approval from the laboratory supervisor for use may be required.
  - b. A designated area conspicuously marked with warning and restricted access signs should be established for the use of chemical carcinogens/suspect carcinogens. All transfers and work with the substance must be conducted in this controlled area. This may be a restricted access hood, glove box, or portion of a laboratory for which all persons with access are aware of the

- 
- 
- substances being used and the necessary precautions.
- c. Containers of these substances should be unbreakable, chemically resistant, appropriately labeled with identity and warning labels, and should be stored only in a ventilated, limited access area in secondary containers.
  - d. Vacuum pumps should be appropriately protected against contamination by scrubbers or HEPA filters vented into a hood. Vacuum pumps or other contaminated equipment including glassware should be decontaminated in the hood before removing them from the controlled area.
  - e. Decontamination of the designated area should occur before normal work is resumed. A chemical-specific decontamination procedure should be provided in the written SOP.
  - f. All protective apparel should be removed and placed in an appropriate, labeled container prior to leaving the designated area. Personnel should thoroughly wash their hands, forearms, face and neck. Contaminated protective apparel and other items such as pipettes, paper towels, etc. should be decontaminated or disposed of by incineration coordinated by the EHSO.
  - g. The use of some carcinogens/suspect carcinogens may warrant the need for medical surveillance. Contact the EHSO, who will then coordinate with the University's occupational health service regarding the possibility or necessity of medical surveillance.
  - h. Accurate records should be kept of the amounts of these substances being stored and used, the dates of use, and the names of the users.
  - i. Contingency plans, spill clean up kits, and proper personal protective equipment should be readily available in case of an accident.
4. If animal work with chemical carcinogens must be performed, use the following protocol.
- a. When possible, administer the substance by injection or gavage instead of in the diet. If administration must be in the diet, use a caging system under negative pressure or under laminar flow directed towards HEPA filters.
  - b. Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces. Examples of such methods include using HEPA filtered

---

---

vacuum equipment for cleaning, moistening contaminated bedding before removal from the cage, and mixing diets in closed containers in a hood.

- c. When working in the animal room, wear plastic or rubber gloves and a fully buttoned laboratory coat or jumpsuit. If the material is excreted from the animal, respiratory protection (not a surgical mask) should be worn when entering the animal room. If respiratory protection is required and worn, a respiratory fit test, training on the use of respirators, and a medical evaluation is required. Contact the EHSO for assistance on this.
- d. Animal tissues, carcasses, excreta and other materials contaminated with carcinogenic or cytotoxic/antineoplastic material must be identified as such when taken to Animal Resources, so that the material may be labeled for disposal by incineration.

Source: OSHA *Occupational Exposure to Hazardous Chemicals in Laboratories* Standard (29 CFR 1910.1450)

## F. Hazardous Drugs

A list of hazardous drugs, which includes cytotoxic/antineoplastic agents, for which these procedures must be followed may be found in Appendix A of this manual.

### 1. Drug Preparation Precautions

#### a. Personal Protective Equipment

##### (1) Gloves

- (a) Surgical latex gloves should be used for the preparation of hazardous drugs unless the manufacturer specifically stipulates that some other glove provides better protection.
- (b) Thicker, longer latex gloves that cover the gown cuff are recommended.
- (c) Individuals with latex allergy should consider the use of vinyl or nitrile gloves or glove liners.
- (d) Gloves with minimal or no powder are preferred since the powder may absorb contamination.
- (e) Double gloving is recommended if it does not interfere with an individual's technique.
- (f) Because all gloves are to some extent permeable

and their permeability increases with time, they should be changed regularly (hourly is preferable) or immediately if they are torn or punctured.

- (g) Hands should always be washed before gloves are put on and after they are removed.

## (2) Gowns

- (a) A protective disposable gown made of lint-free low permeability fabric with a closed front, long sleeves, and elastic or knit-closed cuffs should be worn, with the cuffs tucked under the gloves.
- (b) If double gloves are worn, the outer glove should be over the gown cuff and the inner glove should be under the gown cuff.
- (c) When the gown is removed, the inner glove should be removed last.
- (d) Gowns and gloves in use should not be worn outside the preparation area.

## (3) Respirators

- (a) A biological safety cabinet (BSC) is essential for preparation of hazardous drugs, but where one is not currently available, a NIOSH approved respirator with a high efficiency filter (preferably a powered air-purifying respirator), used by personnel who have been trained to use respirators and have met the medical monitoring and fit test requirements identified in the *OU Respiratory Protection Program*, will provide the best protection until the BSC is installed. Permanent respirator use as a substitute for the use of a BSCs is considered imprudent practice by OSHA.
- (b) Surgical masks do **not** protect against the breathing of aerosols.

## (4) Eye and Face Protection

- (a) Whenever splashes, sprays, or aerosols of hazardous drugs may be generated, which can result in eye, nose, or mouth contamination, or if a BSC is not in use, face and eye protection should

be provided such as a plastic face shield and splash goggles. Eye glasses with temporary side shields are not appropriate.

(b) Eyewash facilities should be made available.

b. Protective Equipment Disposal and Decontamination

(1) All gowns, gloves, and disposable materials used in preparation should be disposed of as hazardous drug waste as described in Section V.I.1. "Hazardous Drug Waste Disposal".

(2) Goggles, face shields, and respirators may be cleaned with mild detergent and water for reuse.

c. Preparation Work Area

(1) It is recommended that all hazardous drugs be prepared in a restricted, preferably centralized area. If this is not practical, the number of areas used for preparation should be minimized.

(2) Warning signs designating the area as a hazardous drug preparation area and restricting the access of unauthorized personnel should be prominently displayed. Spill procedures should also be posted.

(3) Eating, drinking, smoking, chewing gum, applying cosmetics, and storing food in the preparation area should be prohibited.

(4) A class II or III Biological Safety Cabinet (BSC) should be used.

(a) If possible, a dedicated BSC, where only hazardous drugs are prepared is recommended.

(b) Decontamination should occur in accordance with the manufacturer's recommended frequency, whenever spills occur, and when the cabinet requires moving, service or certification.

i) Decontamination consists of surface cleaning with water and detergent followed by thorough rinsing.

ii) Quaternary ammonium cleaners should be avoided due to the possibility of vapor build-

- 
- 
- up in recirculated air.
  - iii) Ethyl alcohol may be used with the cleaner if the contamination is soluble only in alcohol and where the BSC is vented to the outside and air is not recirculated.
  - iv) Ordinary decontamination procedures, which include fumigation with a germicidal agent, are inappropriate in a BSC used for HDs because such procedures do not remove or deactivate the drug.
  - v) Removable work trays, if present, should be lifted in the BSC so the back and the sump below can be cleaned.
  - vi) During cleaning, the worker should wear a respirator, gown, double latex gloves, and splash goggles or other suitable eye protection.
  - vii) All materials from the decontamination process should be handled as hazardous drug waste as described in Section V.I.1. "Hazardous Drug Waste Disposal".
- (c) The blower on the vertical airflow hood should be on at all times, 24 hours/day, 7 days/week. If the BSC is turned off, it should be decontaminated and covered in plastic until airflow is resumed.
- (d) The BSC should be equipped with a continuous monitoring device to allow confirmation of adequate air flow and cabinet performance.
- (e) Venting to the outside is preferable where feasible. If the hood has an outside exhaust system, it should be vented away from air intake units.
- (f) BSCs must be certified by a qualified technician at least annually, after maintenance, or any time the cabinet is moved. High efficiency particulate air (HEPA) filters should be changed when they restrict airflow or if they are contaminated by a spill.
- i) Technicians servicing these cabinets or changing HEPA filters should be notified of the hazardous drugs present/used and potential risks and should wear a respirator, gown, double latex gloves, and splash goggles or other suitable eye protection.
  - ii) Removed HEPA filters should be disposed

---

---

of as hazardous drug waste as described in Section V.I.1. "Hazardous Drug Waste Disposal".

d. Preparation Work Equipment

- (1) Work with hazardous drugs should be carried out in a BSC on a disposable, plastic-backed paper liner, which should be changed after preparation is completed for the day or after a shift, whichever comes first, or immediately after a spill.
- (2) Syringes and IV sets with Luer-lock fittings should be used, and syringes should always be large enough so that they are not full when the entire drug dose is present.
- (3) A covered disposable container should be used to contain excess solution.
- (4) A covered sharps container should be in the BSC. All syringes and needles used in the course of preparation should be placed in the sharps container without being crushed, clipped or capped.
- (5) Hazardous drug waste bags or containers should be available for all contaminated materials such as gloves, gowns, and paper liners.

e. Work Practices in Preparation

- (1) Aseptic technique is standard practice for drug preparation.
- (2) All personal protective equipment should be donned before work is started in the BSC.
- (3) All items necessary for drug preparation should be placed within the BSC before work is begun and all extraneous items should be kept out of the work area in order to avoid contamination.
- (4) Since BSC benches differ from horizontal flow units in several ways, manipulations should not be performed close to the work surface of a BSC and unsterilized items, including liners and hands must be kept downstream from the working area. Entry and exit of the cabinet should be perpendicular to the front, and rapid lateral hand movement should be avoided.

- 
- 
- (5) All syringes and IV bags containing hazardous drugs should be labeled with a distinctive warning labels such as "special handling/disposal precautions required", and should be labeled with the chemical name and hazard warning, such as "cytotoxic", or "hazardous drug".
  - (6) Drug administration sets should be attached and primed within the BSC, prior to addition of the drug to eliminate the need to prime the set in a less well-controlled environment, and to ensure that any fluid that escapes during priming contains no drug.
  - (7) Extremes of positive and negative pressure in medication vials should be avoided.
    - (a) The use of large-bore needles, #18 or #20, avoids high-pressure syringing of the solutions. However, some experienced personnel believe that large-bore needles are more likely to drip. Multi-use dispensing pins are recommended to avoid these problems.
    - (b) Venting devices such as filter needles or dispensing pins permit outside air to replace the withdrawn liquid.
    - (c) Although venting devices are recommended, another technique is to add diluent slowly to the vial by alternately injecting small amounts, allowing displaced air to escape into the syringe. When all diluent has been added, a small amount of additional air may be withdrawn to create a negative pressure in the vial, but this should **not** be expelled into room air because it may contain drug residue. It should either be injected into a vacuum vial or remain in the syringe to be discarded.
  - (8) Handling Ampules
    - (a) Ampules with dry material should be gently tapped down before opening to move any material in the top of the ampule to the bottom quantity.
    - (b) A sterile gauze pad should be wrapped around the ampule neck before breaking the top to protect against cuts and catch airborne powder or aerosol.
    - (c) If diluent is to be added, it should be injected slowly

down the inside wall of the ampule. The ampule should be tilted gently to ensure that all the powder is wet before agitating it to dissolve the contents.

- (d) After the solution is withdrawn from the ampule with a syringe, the needle should be cleared of solution by holding it vertically with the point upwards, the syringe should be tapped to remove air bubbles and the air bubbles expelled into a closed container.

## 2. Non-liquid Hazardous Drugs

- a. Tablets which may produce dust or potential exposure to the handler should be counted in a BSC. Automated counting machines should not be used unless an enclosed process isolates the hazard from the employee.
- b. Compounding should occur in a BSC or a NIOSH-approved respirator should be worn. A gown and gloves should also be worn.

## 3. Packaging and Transport

- a. The outside of bags or bottles containing the prepared drug should be wiped with moist gauze.
- b. Entry ports should be wiped with moist alcohol pads and capped.
- c. Transport should occur in sealed plastic bags and transported in containers designed to avoid breakage.
- d. Personnel involved in transport of hazardous drugs should be trained in spill procedures.
- e. Hazardous drugs that are shipped are also subject to Department of Transportation (DOT) regulations. For information, contact the EHSO.

## 4. Drug Administration

- a. Personal Protective Equipment
  - (1) Personnel administering hazardous drugs should wear gowns, latex or other appropriate gloves, and chemical splash goggles or equivalent safety glasses.
  - (2) NIOSH-approved respirators should be worn when

---

---

administering aerosolized drugs.

b. Work Practices

- (1) Hands should be washed before donning and after removing gloves.
- (2) Gowns or gloves that become contaminated should be changed immediately.
- (3) Infusion sets and pumps, which should have Luer-lock fittings should be observed for leakage during use. A plastic backed absorbent pad should be placed under the tubing during administration to catch any leakage. Sterile gauze should be placed around any push sites; IV tubing connecting sites should be taped.
- (4) Priming IV sets or expelling air should be carried out in a BSC. If priming must occur at the administration site, the line should be primed with non-drug containing solution or a back-flow system should be used.
- (5) Syringes, IV bottles and bags, and pumps should be wiped clean of any drug contamination with sterile gauze. Needles and syringes should not be crushed or clipped, but should be placed in a puncture resistant sharps container then into a hazardous drug disposal bag with all other contaminated materials. The bag should be disposed as hazardous drug waste as described in Section V.I.1. "Hazardous Drug Waste Disposal".
- (6) Administration sets should be disposed of intact, in accordance with the procedures in Section V.I.1. "Hazardous Drug Waste Disposal".
- (7) Protective goggles should be cleaned with detergent and properly rinsed.
- (8) All protective equipment should be disposed of upon leaving the patient care area.

5. Spills

Spills and breakages should be cleaned up immediately by a properly protected person trained in the appropriate procedures. Refer to Section XII.H., "Cytotoxic/Antineoplastic and Other Hazardous Drug Spills" for additional information.

## 6. Storage Areas

- a. Access to areas where hazardous drugs are stored should be limited to authorized personnel with signs restricting entry.
- b. A list of all drugs covered by hazardous drug policies and information on spill and emergency response procedures should be posted or easily available to employees.
- c. Facilities used for storing hazardous drugs should not be used for other drugs and should be designed to prevent containers from falling to the floor.
- d. Warning labels should be applied to all hazardous drug containers, as well as the shelves and bins where these containers are permanently stored.

## 7. Receiving Damaged Hazardous Drug Packages

- a. Damaged cartons should be opened in an isolated area by an employee wearing double gloves, a gown, goggles, and a NIOSH-approved respirator.
- b. Broken containers and contaminated packaging should be placed in a sharps container if possible, and then into hazardous drug disposal bags.
- c. The appropriate protective equipment and waste disposal materials should be kept in the area where shipments are received and employees should be trained in their use and the risks of exposure to hazardous drugs.

## 8. Training and Information Dissemination

- a. All personnel involved in any aspect of the handling of hazardous drugs (shipment-receiving personnel, physicians, nurses, pharmacists, housekeepers, or employees involved in the transport or storage of drugs) must receive information and training to apprise them of the hazards of the hazardous drugs present in the work area. The information and training should include:
  - (1) information on any operation/procedure in their work area where drugs that present a hazard are present,
  - (2) methods and observations that may be used to detect the presence or release of a hazardous drug in the work area (such as monitoring conducted, continuous monitoring

- 
- 
- devices, visual appearance or odor),
  - (3) the physical and health hazards of the hazardous drugs, including carcinogenic and reproductive hazard potential,
  - (4) the measures employees can take to protect themselves from these hazards (including appropriate work practices, emergency procedures, and personal protective equipment), and
  - (5) hazard communication training as required by the OU *Hazard Communication Policy and Program*.
- b. This information should be provided at the time of an employee's initial assignment to a work area where hazardous drugs are present and prior to assignments involving new hazards. Annual refresher information and training is required.
  - c. Knowledge and competence of personnel should be evaluated after the first orientation or training session and at least annually thereafter.
    - (1) Evaluation may involve direct observation of an individual's performance on the job.
    - (2) Non-hazardous solutions may be used for evaluation of preparation techniques. Quinine, which will fluoresce under ultraviolet light, provides a easy mechanism for evaluation of technique.
9. Medical Surveillance
- a. All employees with potential exposure to hazardous drugs through preparation, administration, housekeeping, waste disposal, transport or storage should receive an initial medical evaluation by an occupational physician consisting of a history, physical exam, and laboratory studies.
  - b. These exams should be repeated at an interval determined by the occupational physician.

Source: OSHA Technical Manual (TED1-0.15A), Section VII; Chapter 2, "Controlling Occupational Exposure to Hazardous Drugs"

## G. Formaldehyde

### 1. Scope and Application

- a. The OSHA *Formaldehyde* Standard applies to all occupational

---

---

exposures to formaldehyde, i.e. from formaldehyde gas, its solutions, and materials that release formaldehyde.

- b. The purpose of the regulation is to assure that no employee is exposed to an airborne concentration of formaldehyde which exceeds the OSHA permissible exposure limits (PELs) of 0.75 ppm as an 8-hour time weighted average (TWA) or 2.0 ppm as a 15-minute short term exposure limit (STEL).
- c. The "action level" for this standard is defined as a concentration of 0.5 ppm calculated as an 8-hour TWA concentration.

## 2. Exposure Monitoring

- a. Initial air monitoring should occur to determine whether employee exposures to formaldehyde exceed the action level or the STEL. The EHSO will perform monitoring:
  - (1) whenever the EHSO identifies a work area that has the potential for airborne formaldehyde,
  - (2) whenever employees are exhibiting signs or symptoms of overexposure to formaldehyde, and
  - (3) at the request of an employee or department.
- b. Monitoring protocol will follow the requirements established in the regulation.
- c. Employees should be notified within 15 days of receipt of the laboratory results by the EHSO. The EHSO will provide the supervisor with a written report which must be distributed to all affected employees.
- d. If the employee exposure is over either PEL, the EHSO will assist the department with the development and implementation of a written plan to reduce employee exposure to or below both PELs, give written notice to employees and provide the necessary additional training. The written notice shall contain a description of the corrective action being taken by the employer to decrease exposure.
- e. If the employee exposure is >0.1 ppm, the EHSO will assist the department with the required additional training as described in Section IV.G.10.b., "Training".
- f. Employees may observe any monitoring of employee exposure to formaldehyde required by this standard.

### 3. Regulated Areas

- a. Regulated areas must be established where the concentration of airborne formaldehyde exceeds either PEL.
- b. All entrances and accessways to these areas must be posted with signs bearing the following information:

DANGER  
FORMALDEHYDE  
IRRITANT AND POTENTIAL CANCER HAZARD  
AUTHORIZED PERSONNEL ONLY

- c. Access to these areas shall be limited to authorized persons who have been trained to recognize the hazards of formaldehyde.

### 4. Methods of Compliance

- a. Engineering controls and work practice controls shall be utilized to reduce and maintain employee exposures to formaldehyde at or below either PEL.
- b. Whenever feasible engineering and work practice controls cannot reduce employee exposure to or below either of the PELs, these controls shall be applied to reduce employee exposures to the extent feasible and respirators must be supplied to affected employees. Should this occur, the EHSO must be notified to ensure the proper respirator selection and coordinate compliance with additional OSHA regulations regarding respirator use.

### 5. Protective Equipment and Clothing

- a. When needed, the department must provide protective equipment or clothing at no cost to the employee and assure that the employee wears them.
- b. The department, in coordination with the EHSO, shall select protective clothing and equipment based upon the form of formaldehyde to be encountered, the conditions of use, and the hazard to be prevented.
  - (1) All contact of the eyes and skin with liquids containing 1 percent or more formaldehyde shall be prevented by the use of chemical protective clothing made of material impervious to formaldehyde and the use of other personal protective equipment, such as goggles and face shields, as appropriate to the operation.

- 
- 
- (2) Contact with irritating or sensitizing materials shall be prevented to the extent necessary to eliminate the hazard.
  - (3) Where a face shield is worn, chemical safety goggles are also required.
  - (4) Full body and respiratory protection shall be worn for entry into areas where concentrations exceed 100 ppm and for emergency reentry into areas of unknown concentration.
- c. The department must assure that protective equipment and clothing that has become contaminated with formaldehyde is cleaned or laundered at no cost to the employee before reuse.
  - d. When ventilating formaldehyde-contaminated clothing and equipment, the department must establish a storage area so that employee exposure is minimized. Containers for contaminated clothing and equipment and storage areas must have labels and signs containing the following information:

DANGER  
FORMALDEHYDE-CONTAMINATED [CLOTHING] EQUIPMENT  
AVOID INHALATION AND SKIN CONTACT

- e. The department must assure that only persons trained to recognize the hazards of formaldehyde remove the contaminated material from the storage area for purposes of cleaning, laundering, or disposal.
  - f. No employee may take home equipment or clothing that is contaminated with formaldehyde.
  - g. The department must repair or replace all required protective clothing and equipment for each affected employee as necessary to assure its effectiveness.
  - h. The department must inform any person who launders, cleans, or repairs such clothing or equipment of formaldehyde's potentially harmful effects and of procedures to safely handle the clothing and equipment.
6. Hygiene Protection
- a. If employees are required to change from work clothing into protective clothing to prevent skin contact with formaldehyde, a change room is required.
  - b. If the potential exists for employees' skin to become splashed with

---

---

solutions containing 1 percent or greater formaldehyde, drench showers must be available within the immediate area for emergency use.

- c. If the potential exists for employee's eyes to be splashed with solutions containing 0.1 percent or greater formaldehyde, acceptable eyewash facilities must be available within the immediate work area for emergency use.

## 7. Housekeeping

- a. The department must establish procedures for employees to recognize leaks and/or spills, containment of any spill, decontamination of the work area, and disposal of the waste.
- b. Spills must be cleaned in a proper manner wearing suitable protective equipment.
- c. Formaldehyde-contaminated waste and debris resulting from leaks or spills must be labeled with a warning of formaldehyde's presence and of the hazards associated with formaldehyde. Contact the EHSO for proper disposal procedures.

## 8. Medical Surveillance

- a. The department, in conjunction with the EHSO, must establish a medical surveillance program that meets the requirements of the OSHA standard when:
  - (1) employees are exposed to formaldehyde at concentrations at or exceeding the action level or exceeding the STEL,
  - (2) employees have developed signs or symptoms of overexposure to formaldehyde, and
  - (3) employees are exposed to formaldehyde in emergencies.
- b. All medical procedures shall be performed by or under the 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.
- c. For each examination required under this standard, the department will obtain a written opinion from the examining physician. This written opinion shall contain the results of the medical examination except that it shall not reveal specific findings or diagnoses unrelated to occupational exposure to formaldehyde.

- 
- 
- d. The department must retain the results of the medical examination and tests conducted by the physician and provide a copy of the physician's written opinion to the affected employee within 15 days of its receipt.
  - e. Medical removal provisions are provided for in the OSHA standard. Any medical removal that occurs at OU must comply with the provisions of the OSHA standard and any other applicable OU policy.
9. Labeling
- a. All materials capable of releasing formaldehyde at levels of 0.1 ppm to 0.5 ppm must be labeled with information that identifies that the product contains formaldehyde; the name and address of the responsible party must be listed; and a statement that physical and health hazard information is readily available from the department and from MSDSs.
  - b. All materials capable of releasing formaldehyde at levels above 0.5 ppm, must be labeled with information that addresses all hazards as defined in 29 CFR 1910.1200(d) and 29 CFR 1910.1200 appendices A and B, including respiratory sensitization, and shall contain the words 'Potential Cancer Hazard'. Copies of this regulation may be obtained from the EHSO.
10. Education and Training
- a. Employees who work with formaldehyde must be trained in the hazards of formaldehyde under the OU *Hazard Communication Policy and Program*. As a minimum, specific health hazards that the employer shall address are: cancer, irritation and sensitization of the skin and respiratory system, eye and throat irritation, and acute toxicity.
  - b. Employees who are assigned to workplaces where there is exposure to formaldehyde at or above 0.1 ppm must be provided with training which includes:
    - (1) a discussion of the contents of the OSHA regulation and the contents of the MSDS;
    - (2) the purpose for and a description of the medical surveillance program required by this standard, including:
      - (a) a description of the potential health hazards associated with exposure to formaldehyde and a

- 
- 
- description of the signs and symptoms of exposure to formaldehyde, and
- (b) instructions to immediately report to their supervisor the development of any adverse signs or symptoms that the employee suspects is attributable to formaldehyde exposure;
  - (3) a description of operations in the work area where formaldehyde is present and an explanation of the safe work practices appropriate for limiting exposure to formaldehyde in each job;
  - (4) the purpose for, proper use of, and limitations of personal protective clothing and equipment;
  - (5) instructions for the handling of spills, emergencies, and clean-up procedures;
  - (6) an explanation of the importance of engineering and work practice controls for employee protection and any necessary instruction in the use of these controls; and
  - (7) a review of emergency procedures including the specific duties or assignments of each employee in the event of an emergency.
- c. Employees must be provided with such information and training on formaldehyde at the time of their initial assignment, whenever a new hazard from formaldehyde is introduced into their work area, and at least annually thereafter.

Source: OSHA *Formaldehyde Standard* (29 CFR 1910.1048)

## H. Peroxide-Forming Chemicals

Some chemicals, including ethers, aldehydes, alkenes, liquid paraffins, and olefins can decompose and form peroxides on exposure to air and light. Since these chemicals are packaged in an air atmosphere, peroxides can form even though the containers have not been opened. Examples of potential peroxide-forming materials are included in Appendix B of this manual.

The most commonly found group of peroxide-forming chemicals in teaching and research laboratories are ethers, including ethyl, isopropyl, dioxane, tetrahydrofuran, and other ethers. Specific safety procedures for working with ethers are as follows.

1. The primary hazard of ethers are not toxicity, but rather flammability. This property, along with extreme volatility and the tendency of their vapors to flow along surfaces to an ignition source make them a very dangerous fire

---

---

hazard.

- a. Ethyl ether's wide flammability range (1.8 - 36.5% in air) and low flashpoint (-49°F) make it extremely dangerous. This danger exists from the moment of a spill or release of vapors from a breached container. Only at temperatures colder than -49°F will the vapor not ignite.
  - b. Ethyl ether is also very explosive. Its vapors can explode whenever hot metal, super-heated steam or other material at a temperature of 320°F or higher comes into contact with the vapors.
2. Another hazard of ethers is the tendency to form unstable peroxides. Organic peroxides are extremely explosive and are sensitive to shock, heat or friction. Laboratory personnel have been fatally injured or severely disabled by such explosions.
- a. The major cause of peroxide formation is the process of opening a container, exposing its contents to air, and then closing the container. Peroxide crystals then form on the threads of the cap and/or neck of the container, and the energy generated from the friction caused by turning the cap can "set it off".
  - b. Gross evidence of peroxide formation is indicated by the presence of crystalline solids in the container, however, levels of 50 ppm or less of peroxides can be hazardous.
  - c. Peroxide concentrations will increase in the container as the volume of liquid decreases due to volatility and evaporation.
3. The following procedures will help minimize the hazards of ethers.
- a. Always wear safety glasses or a face shield and safety glasses when working with ethers. Whenever possible, work in a fume hood with the sash down as far as possible.
  - b. Purchase ethers in small quantities and only order them when needed.
  - c. Date containers of ether when opened.
  - d. Frequently test opened containers of ethyl ether with peroxide test strips (which can be ordered through a laboratory supply catalog) and write the concentration of peroxide on the label of the container or a sticker applied to the container.
    - (1) When the peroxide concentration reaches 25 ppm, contact

---

---

the EHSO for disposal.

- (2) Open containers of ethyl ether with unknown peroxide concentrations are **extremely** expensive to dispose. If you do not identify the peroxide content on an opened container of ether, you may be asked to test it before it is picked up, unless the container is very old or other conditions indicate this would be a hazardous endeavor.
- e. Closed containers of ethers should be discarded after one year from purchase or by the date identified on the container label. Contact the EHSO for disposal. Contact the EHSO for disposal.

Any peroxidizable chemical with visible discoloration, crystallization, or liquid stratification should be treated as potentially explosive. Contact EHSO for assistance.

Sources: Association of Official Analytical Chemists, *The Referee*, August 1989  
Chemical Rubber Company *Handbook of Laboratory Safety*  
National Research Council, *Prudent Practices for Handling Hazardous Chemicals in Laboratories*

#### I. **Incompatible Chemicals**

Certain hazardous chemicals cannot be safely mixed or stored with other chemicals because a severe reaction can take place or an extremely toxic byproduct will result. The chemical label and MSDS will contain information on incompatibilities. A partial list of incompatible chemicals is included in Appendix C of this manual.

#### J. **Shock-Sensitive Chemicals**

Shock-sensitive chemicals may decompose rapidly or explode when struck, vibrated, or otherwise agitated. Therefore, it is important to wear appropriate personal protective equipment and work in a chemical fume hood when handling shock-sensitive chemicals.

Many chemicals become increasingly shock-sensitive with age. The date received and date opened should be clearly marked on all containers of shock-sensitive chemicals. Unless an inhibitor was added by the manufacturer, closed containers of potentially shock-sensitive materials should be discarded after one year if unopened. Shock-sensitive materials should be discarded six months after opening. Please contact the EHSO for disposal procedures.

The label and MSDS will indicate if a chemical is shock-sensitive. A partial list of potentially shock-sensitive materials is listed in Appendix D of this manual.

The most commonly found shock-sensitive chemical in the research laboratory is picric acid. Even wetted picric acid is shock-sensitive and is classified as a Department of Transportation Division 1.1 explosive. However, picric acid forms salts which are more sensitive than the wetted picric acid. Procedures for working with picric acid are as follows:

1. Keep the water content of any container of picric acid above 10%.
2. Salt formation is enhanced through contact with metals, concrete, ammonia, and bases. Avoid contact with these materials.
3. Age or improper storage may cause small crystals to develop and lodge in the threads of the cap to the container. Explosions can occur when the cap is removed. If this possibility exists, do not attempt to open the container and contact the EHSO immediately.

Sources: N. I. Sax, *Dangerous Properties of Industrial Materials*  
J. P. Dux, *Managing Safety in the Chemical Laboratory*

#### K. Explosive Materials

1. Explosive materials are substances that need to be carefully managed due to their volatile nature. Appendix H contains a comprehensive, but not all inclusive, list of explosive materials. Explosive materials include any and all mixtures containing any of the materials on the list.
2. An integral part of managing explosive materials is to properly store them using the following guidelines:
  - a. Containers should be stored so that they can easily be counted and checked upon inspection.
  - b. Except with respect to fiberboard or other nonmetal containers, containers of explosive materials should not be unpacked or re-packed close to other explosive materials.
  - c. Containers of explosive material must be closed during storage.
  - d. Tools used for opening or closing containers of explosive materials are to be of non-sparking materials, except that metal slitters may be used for opening fiberboard containers. A wood wedge and a fiber, rubber, or wooden mallet are to be used for opening and closing wood containers or explosive materials. Metal tools should not be stored in any magazine containing high explosives.
3. Any loss or theft of an explosive material must be reported to the Bureau of Alcohol, Tobacco, Firearms, and Explosives. Contact Campus Police if a loss or theft of an explosive material from your laboratory has occurred.

Source: Bureau of Alcohol, Tobacco, Firearms, and Explosives Regulations (27 CFR 555)

#### L. Allergens/Sensitizers

Allergens and sensitizers are substances that can produce dermal and/or respiratory

---

sensitivity with symptoms such as an allergic rash or asthma-like symptoms. A list of reported allergens/sensitizers may be found in Appendix E. Once sensitization occurs, a very small exposure can result in a significant reaction.

1. Wear suitable gloves to prevent skin contact.
2. Work in a chemical hood when airborne aerosols, vapors or particulates of the material may be generated.
3. Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.

Source: OSHA *Occupational Exposure to Hazardous Chemicals in Laboratories* Standard (29 CFR 1910.1450, Appendix A, National Research Council Recommendations Concerning Chemical Hygiene in Laboratories)

#### **M. Embryotoxins/Reproductive Hazards**

These substances have the capability of affecting either the reproductive capacity of the exposed person or the development of their progeny. A list of reported agents that can cause reproductive hazards may be found in Appendix F, "Reported Potential Reproductive Hazards". Note that some of the compounds listed may only pose a hazard through ingestion of large quantities. The hazard of each listed compound should be reviewed based on the potential exposure to the worker.

1. Establish a designated area for the use of these materials, conspicuously marked with warning signs, where all persons with access are aware of the substance(s) in use, the hazards, and the protective measures.
2. Where the potential for airborne particles, vapors, or gases of these substances exists, handle these substances only in a hood whose satisfactory performance has been confirmed.
3. Always use appropriate protective apparel (especially gloves) to prevent skin contact.
4. Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.
5. Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.

Source: OSHA *Occupational Exposure to Hazardous Chemicals in Laboratories* Standard (29 CFR 1910.1450, Appendix A, National Research Council Recommendations Concerning Chemical Hygiene in Laboratories)

#### **N. Chemicals of Moderate Chronic or High Acute Toxicity**

These materials do not constitute a significant carcinogenic or other long-term hazard but can be dangerous to those exposed to high doses or repeated small doses.

---

Examples are diisopropylfluorophosphate, hydrofluoric acid, and hydrogen cyanide. These precautions are appropriate for substances with moderate chronic or high acute toxicity when used in significant quantities.

1. Use and store these substances only in designated areas of restricted access with special warning signs.
2. Always use a hood on which satisfactory performance has been confirmed with a face velocity of at least 60 linear feet per minute or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance; trap released vapors to prevent their discharge with the hood exhaust.
3. Avoid skin contact by use of gloves, long sleeves, and other protective apparel as appropriate.
4. Wash hands and arms immediately after working with these materials.
5. Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved.
6. Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity.
7. Store breakable containers of these substances in chemically resistant trays.
8. Place chemically resistant trays under work and under apparatus.
9. Cover work and storage surfaces with removable, absorbent, plastic backed paper.
10. If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment.
11. Unless thorough decontamination is performed, dispose of contaminated clothing as hazardous waste.

Source: OSHA Occupational Exposure to Hazardous Chemicals in Laboratories Standard (29 CFR 1910.1450, Appendix A, National Research Council Recommendations Concerning Chemical Hygiene in Laboratories)

## **O. Inhalation Anesthetics**

Inhalation anesthetics can present potential health hazards to personnel who administer such agents, including nausea, dizziness, headaches, fatigue, irritability, sterility, miscarriages, birth defects, cancer, and liver and kidney disease. Some anesthetics, such as dimethyl ether, are extremely flammable, and thus also pose a safety hazard.

OSHA and the National Institute for Occupational Safety and Health (NIOSH)

---

---

recommend limiting employee exposure to nitrous oxide, when used as the sole anesthetic agent, to concentrations no greater than 25 ppm as an eight-hour time weighted average (TWA). Exposure to halothane, methoxyflurane, enflurane, and fluroxene (halogenated anesthetics) should be limited to no more than 2 parts per million (ppm). When halogenated agents are used in combination with nitrous oxide, control of nitrous oxide to a concentration of 25 ppm during the anesthetic administration period will result in levels of about 0.5 ppm of the halogenated agent.

Ideally, inhalant anesthetics should be administered via an anesthetic machine that has a scavenging system attached to the release valve. In addition, a strict inspection and maintenance program regarding the anesthetic unit will also minimize potential leak sources. Reducing anesthetic gas flow rates, whenever possible, can significantly lower concentrations of anesthetic gases in the environment.

Safety and health concerns and precautions for commonly used inhalation anesthetics are presented in Table IV-1.

- Sources: D.F. Liberman and J.G. Gordon, *Biohazards Management Handbook*, Marcel Dekker. Inc., 1989  
P. Flecknell, *Laboratory Animal Anaesthesia*, Academic Press, 1996  
OSHA , *Waste Anesthetic Gases*, OSHA Fact Sheet No. OSHA 91-38, 1991  
NIOSH, NIOSH ALERT: *Controlling Exposures to Nitrous Oxide During Anesthetic Administration*, DHHS (NIOSH) Publication No. 94-100, 1994  
NIOSH, *Criteria for a Recommended Standard...Occupational Exposure to Waste Anesthetic Gases and Vapors*, NIOSH Publication No. 77-140,1977  
AVMA, *2000 Report of the AVMA Panel on Euthanasia*, Journal of the American Veterinary Medical Association, Vol. 218(5):669-696, March 1, 2001 (et seq.)

TABLE IV-1  
SAFETY AND HEALTH CONCERNS AND PRECAUTIONS FOR COMMONLY USED INHALATION ANESTHETICS

Compound	Exposure Limit	Health Effects/Signs of Overexposure	Precautions
ETHER	400 ppm (8 hr. avg.), 1200 ppm short term (15 min. avg.)	<ul style="list-style-type: none"> <li>• General anesthesia by inhalation: continued exposure may lead to respiratory failure or death</li> <li>• May cause eye, nose and throat irritation, vomiting, irregular respiration, dizziness, drowsiness, or unconsciousness</li> <li>• Ingestion of 1-2 ounces may be fatal</li> <li>• Irritating to the skin and mucous membranes by drying effect - can cause dermatitis on prolonged exposure</li> <li>• Prolonged exposures to high concentrations of vapor can cause eye damage</li> <li>• Repeated exposures may be habit forming - prolonged exposures may result in headache, drowsiness, excitation, and psychic disturbances</li> <li>• Teratogenic effects are possible</li> <li>• Persons with pre-existing skin disorders or eye problems or impaired liver, kidney or respiratory function may be more susceptible to the effects of this substance</li> </ul>	<p>Ether has a low flash point, high vapor pressure, is extremely flammable and an explosion hazard. Ether should be used only in approved, well-ventilated areas, and should be administered whenever possible in an operating fume hood. Signs forbidding smoking, cauteries, open flames and sparking motors should be posted.</p> <p>Because the liquid anesthetic is a skin irritant, the cotton or gauze must be placed under a raised wire floor and the animals exposed to vapors only. Humans should also prevent skin exposure through the use of appropriate gloves (nitrile is recommended) and other personal protective equipment. Eye protection is recommended where there is a potential for splash to the face.</p> <p>Ether forms explosive peroxides when stored in metal containers or allowed contact with air. Ether must never be stored in areas or equipment containing non-explosion proof motors or sparking electrical circuitry, and should only be stored in an approved flammable liquid cabinet, an explosion-proof refrigerator, or a fume hood.</p> <p>After death, animals euthanized with ether should be placed in a well-ventilated area for at least 30 minutes before they are transferred to a cooler. This precaution will prevent the accumulation of explosive concentrations of ether.</p>
HALOTHANE	2 ppm	<ul style="list-style-type: none"> <li>• Is hepatotoxic and a possible carcinogen or mutagen - long-term or repeated exposures may have effects on the liver</li> <li>• May cause reproductive toxicity in humans</li> <li>• May cause coughing, vomiting, shivering cramps, nausea, dizziness, hypothermia, respiratory difficulty, fainting, convulsions</li> <li>• Large doses may cause CNS depression, cardiac arrhythmia, severe hepatitis, hepatic necrosis, muscular relaxation, and unconsciousness</li> <li>• May cause eye redness, tearing and skin irritation, drying of skin, defatting, or dermatitis</li> <li>• Persons with pre-existing skin disorders, eye problems or impaired liver, kidney, CNS or respiratory function may be more susceptible to the effects of this product</li> </ul>	<p>Halothane is a non-flammable anesthetic but has a high vapor pressure so can achieve a vapor concentration of 30% in air or oxygen at room temperature. This characteristic, plus its rapid action, necessitate great care and precise regulation during its use for anesthesia. Halothane should be used only with an anesthetic unit containing a special precision vaporizer designed specifically for this agent.</p> <p>Skin exposure to liquid anesthetic should be prevented through the use of gloves (neoprene, polyvinyl acetate or viton) and other personal protective equipment. Eye protection is recommended where there is a potential for splash to the face.</p>

TABLE IV-1  
SAFETY AND HEALTH CONCERNS AND PRECAUTIONS FOR COMMONLY USED INHALATION ANESTHETICS

Compound	Exposure Limit	Health Effects/Signs of Overexposure	Precautions
ENFLURANE	2 ppm	<ul style="list-style-type: none"> <li>• Irritation of eyes, nose, and throat.</li> <li>• CNS and respiratory depressant</li> <li>• Can impair cardiac performance</li> <li>• May cause death if ingested</li> <li>• Persons with seizure disorders may be more sensitive to this product</li> <li>• Enflurane is a halogenated anesthetic gas. Exposure to these types of halogenated agents have been linked to reproductive problems in women and developmental defects in their offspring</li> </ul>	<p>Enflurane should be used with an anesthetic unit to reduce waste of the anesthetic and protect personnel from inhaling excessive vapor.</p> <p>Skin exposure to liquid anesthetic should be prevented through the use of latex, rubber or other impervious gloves and other personal protective equipment to prevent skin contact. Eye protection is recommended where there is a potential for splash to the face.</p>
METHOXYFLURANE	2 ppm	<ul style="list-style-type: none"> <li>• Causes systemic effects in humans via inhalation - chronic effects of exposure may include nephrotoxicity, hepatotoxicity, teratogenesis, and carcinogenesis</li> <li>• The liquid anesthetic may cause skin irritation; prolonged contact may result in blisters</li> <li>• The substance can be absorbed through intact skin</li> <li>• May cause nausea, vomiting, intoxication, CNS depression, unconsciousness, dizziness, drowsiness, headache and irritation of the upper respiratory tract, eyes, nose, mouth, throat and other mucous membranes</li> </ul>	<p>Methoxyflurane is non-flammable under conditions of normal anesthetic use. It should only be used with an anesthetic unit that maintains a closed or semi-closed system to reduce waste of the anesthetic and to protect personnel from inhaling excessive vapor.</p> <p>Skin exposure to liquid anesthetic should be prevented through the use of latex, rubber or other impervious gloves and other personal protective equipment to prevent skin contact. Eye protection is recommended where there is a potential for splash to the face.</p>
NITROUS OXIDE	25 ppm	<ul style="list-style-type: none"> <li>• Symptoms of overexposure include asphyxiation, hysteria, intoxication dizziness, unconsciousness, death</li> <li>• Chronic exposure to nitrous oxide has been reportedly associated with an increased incidence of spontaneous abortions and an increased incidence of congenital malformations among children of exposed females and wives of exposed males</li> <li>• Has been shown to interfere with the production of blood leukocytes and red blood cells by the bone marrow</li> <li>• Contact with cryogenic liquid or cold vapor may cause frostbite</li> </ul>	<p>Nitrous oxide is a non-flammable gas, rather than a volatile liquid, at atmospheric pressure. It is not potent enough to produce adequate anesthesia when used alone, and may be used to supplement other anesthetics such as methoxyflurane or halothane. Precautions when using nitrous oxide include minimizing the flow of both oxygen and nitrous while still maintaining an adequate concentration of both to achieve the desired effects, and using scavenging systems where possible to trap the waste anesthetic gases.</p>
CARBON DIOXIDE	5000 ppm (0.5%) (8 hr.avg.)	<ul style="list-style-type: none"> <li>• Carbon dioxide will produce a narcosis with rapid anesthesia - inhalation of 60% carbon dioxide results in loss of consciousness within 45 seconds and respiratory arrest within 5 minutes</li> <li>• Symptoms of overexposure include dizziness, headache, elevated blood pressure, tachycardia (rapid heart beat), hyperventilation and unconsciousness</li> </ul>	<p>Carbon dioxide administration to individual animals by inhalation in a chamber is acceptable for small animals, but the chamber should be able to vent into a chemical fume hood or other exhaust system.</p> <p>Compressed gas in cylinders is the only recommended source of carbon dioxide because the inflow to the chamber can be regulated precisely. Carbon dioxide generated by other methods such as from dry ice, fire extinguishers, or chemical means (e.g., antacids) is unacceptable.</p>

TABLE IV-1  
SAFETY AND HEALTH CONCERNS AND PRECAUTIONS FOR COMMONLY USED INHALATION ANESTHETICS

Compound	Exposure Limit	Health Effects/Signs of Overexposure	Precautions
CHLOROFORM	50 ppm	<ul style="list-style-type: none"> <li>• Chloroform is hepatotoxic, nephrotoxic, and a suspected human carcinogen</li> <li>• Irritates respiratory tract and causes CNS effects, including headache, drowsiness, dizziness - exposure to high concentrations may result in unconsciousness and even death, prolonged exposure may lead to death due to irregular heart beat and kidney and liver disorders</li> <li>• Ingestion can cause severe burning in mouth and throat, pain in the chest and vomiting - large quantities may cause symptoms similar to inhalation</li> <li>• Causes skin irritation resulting in redness and pain - contact with liquid has defatting effect and may cause drying, cracking, and dermatitis</li> <li>• Vapors causes pain and irritation to eyes - splashes may cause severe irritation and possible eye damage</li> <li>• Persons with pre-existing skin disorders or eye problems, or impaired liver, kidney or respiratory function may be more susceptible to the effects of the substance</li> </ul>	<p>Although chloroform is non-explosive its use in the presence of a flame may result in the production of phosgene gas.</p> <p>Because of its significant hazard to humans, chloroform is not considered an acceptable method of euthanasia.</p>
ISOFLURANE	2 ppm	<ul style="list-style-type: none"> <li>• Drowsiness - high levels may cause unconsciousness</li> <li>• May be irritating to skin or eyes</li> <li>• Ingestion may be harmful</li> <li>• Isoflurane is a halogenated anesthetic gas. Exposure to these types of halogenated agents have been linked to reproductive problems in women and developmental defects in their offspring,</li> </ul>	<p>Isoflurane should be used with a scavenger system or in a chemical fume hood. If neither is available, air monitoring should be performed to determine potential exposure to personnel.</p> <p>Nitrile or other gloves impervious to organic solvents are recommended when skin contact is possible. Eye protection is recommended where there is a potential for splash to the face.</p> <p>Isoflurane is non-explosive and non-flammable.</p>

---

---

## P. Acrylamide

Acrylamide (monomer) is crystalline powder commonly used in the laboratory as a chemical intermediate to synthesize polyacrylamide gel. The powder is typically weighed and then dissolved in an aqueous buffering solution to initiate polymerization. Polymerization can be initiated by exposure to heat, U.V. light, oxidizers, or peroxides. The monomer is highly reactive, thermally unstable, and may polymerize explosively once the reaction begins. Polyacrylamide gel is used for separation of proteins and DNA sequencing by electrophoresis or electroblotting methods. The toxicological properties differ between exposure to the monomer and polyacrylamide.

### 1. Acrylamide

Acrylamide and buffer solutions containing the monomer can be absorbed through the skin, are suspected carcinogens, are severe neurotoxins which affect the central and peripheral nervous system, and may affect the reproductive system and act as a teratogen.

- a. Wear chemical safety goggles, rubber or neoprene gloves, and apron when working with acrylamide monomer.
- b. Use procedures that minimize generation of acrylamide dust.
- c. Acrylamide should be stored in a tightly-closed container in a cool, dry, well-ventilated area away from sources of heat or ignition. The container should be protected from light and physical damage, and kept separate from reactive or incompatible chemicals.
- d. If acrylamide contacts the skin, immediately wash the area with soap and water.
- e. The EHSO should be called for pick-up and appropriate disposal of monomer-containing waste products.

### 2. Polyacrylamide

One method of reducing the hazard of working with acrylamide monomer and the cost of hazardous waste disposal is to purchase prepared polyacrylamide gels. Polyacrylamide is a relatively safe form of acrylamide that has been polymerized. Even though safe, overexposure to polyacrylamide dusts (dehydrated gels) can cause minor irritation to the eyes, nose and throat. Waste polyacrylamide gels (if not contaminated with other chemicals/biohazards) can be disposed in the lab solid waste trash receptacle.

## Q. Ethidium Bromide

Ethidium bromide is commonly used in molecular biology laboratories for rapid

---

visualization of nucleic acids in electrophoretic gels by reacting with DNA and producing a material which fluoresces under UV light. Ethidium bromide is a strong mutagen, can cause heritable genetic damage, is moderately toxic, and is irritating to the skin, eyes, mouth, and upper respiratory tract. Standard procedures for handling ethidium bromide are as follows:

1. Avoid skin contact. Ethidium bromide may be absorbed through the skin.
  - a. Wear chemical protective gloves such as nitrile gloves.
  - b. Lab coats and closed-toed shoes should be worn.
2. Where there is a potential for splash to the eyes or face, eye/face protection such as a face shield, chemical splash goggles, or safety glasses with side shields should be worn.
3. Any operation involving powder or mists of ethidium bromide should be performed in a chemical fume hood.
4. In case of contact with eyes or skin, immediately flush with copious amounts of water.
5. Where UV light is also used, protect against UV exposure to skin and eyes as well. See Section II.H. for UV light safety precautions.
6. Spill/disposal procedures for ethidium bromide are found in Section V.F.

#### **R. Chemical Handling-Transportation of Chemicals**

Many laboratory accidents occur through the simple operation of carrying chemicals from one place to another or transferring them from one container to another. The chemicals used in a laboratory are often corrosive, toxic, or flammable and any accident involving these has the potential for personal injury. Therefore, it is good practice to assume that **all** chemicals are potentially hazardous and to handle them accordingly.

1. When chemicals are hand carried, they should be placed in an outer container or acid-carrying bucket to protect against breakage or spillage.
2. When chemicals are transported on wheel carts, the cart should be stable under the load and have wheels large enough to negotiate uneven surfaces without tipping or stopping suddenly. Bottles should not be placed near the edge of the cart, nor should they be touching each other or other glassware during transport. Be cautious wheeling the cart over door sills or other possible obstructions.
3. Large quantities of concentrated mineral acids, e.g., sulfuric, nitric, and hydrochloric acids, should be kept in storage rooms, acid cabinets, or chemical transfer rooms. Bottles of concentrated acids should then be

---

---

carried from these storage areas in an approved acid bottle carrier (a plastic container which protects the glass bottle in case it is dropped or strikes against a wall or cabinet).

4. Organic solvents should be stored in specialized flammable storage areas. Solvents should be carried from storage areas in special rubber carriers. Organic solvents can present fire hazards or inhalation hazards if the liquid should spill over a large area. The carriers will help contain the contents for easy clean up and disposal.
5. When large bottles of acids, solvents, or other liquids are transported normally within the laboratory, one bottle should be carried at a time. The bottle should be carried with both hands, one on the neck of the bottle and the other underneath. Avoid the temptation to hook a finger through the glass ring on top of the bottle, allowing it to dangle while being transported. Never carry or attempt to pick up a bottle by the cap.

## S. Chemical Storage

While laboratories may occasionally use relatively large quantities (bulk drums) of certain solvents or acids, the majority of chemicals being stored and used will be in four-liter or smaller containers. The principle concerns in achieving proper storage is to maximize employee safety, ensure chemical compatibility, provide spill and fire/explosion control, provide security and identification, and provide a "user friendly" system with respect to point-of-use. The following guidelines are presented.

1. All containers, except those intended for immediate use, must be labeled with the chemical name and the general hazard of the contents.
2. Hazardous chemicals stored in the open in the laboratory area should be kept at the minimum necessary for the work being done. Chemicals should be returned to their storage location as soon as feasible upon completion of work.
3. Storage locations should be as close as feasible to the point of use in order to maximize efficiency and minimize transport distance.
4. Chemicals should be segregated according to the class of hazard and compatibility restrictions, some of which are listed in Appendix C of this manual. Segregation basically refers to physical separation of containers and isolation of potential spills and releases with the goal of preventing chemical reactions. Hazard classes which require segregated storage areas include organics, acids, bases, reactives, explosives, carcinogens and toxins. Ideally, separate cabinets or isolated areas within a central storage area should be used for segregated storage of incompatibles.
5. Storage areas should be appropriately labeled indicating the type of chemicals being stored, e.g., flammable liquids, corrosives, carcinogens, etc.

6. Glass or breakable containers of hazardous chemicals should not be stored on the floor. Metal containers (5 gallons or more) or drums (15 gallons or more) may be stored on the floor if stored out of traffic areas and an absorbent pad is placed beneath the container to control small drips and spills during pouring of chemicals and to protect the floor.
7. Hazardous chemicals should not be stored in hallways.
8. Containers should be kept on low shelves or in cabinets. Shelves should have a lip on the forward edge or bottles should be stored approximately 2 inches back from the edge to prevent bottles from slipping off. Chemicals tend to "creep" toward and over the edge of a shelf. Shelving units should be securely fastened to the wall or floors, and should be free of crowding. The weight limits of shelves should not be exceeded by the weight of the chemicals.
9. Table IV-2 identifies maximum container sizes for flammable and combustible liquids.
10. Whenever possible, flammable and combustible liquids should be placed in approved flammable storage cabinets which meet the following OSHA and NFPA requirements.
  - a. Storage cabinets should be designed and constructed to limit the internal temperature to not more than 325°F when subjected to a 10-minute fire test using the standard time-temperature curve as set forth in NFPA 251, *Standard Methods of Fire Resistance of Building Construction and Materials*.
  - b. Cabinets should be marked in conspicuous lettering, "FLAMMABLE - KEEP FIRE AWAY."
  - c. Metal cabinets constructed in the following manner are acceptable.
    - (1) The bottom, top, door, and sides of cabinet are at least No. 18 gage sheet iron and double walled with 1 1/2-inch air space.
    - (2) Joints are be riveted, welded or made tight by some equally effective means.
    - (3) The door is provided with a three-point lock, and the door sill is raised at least 2 inches above the bottom of the cabinet.
  - d. Venting of flammable storage cabinets is permitted if vented directly to the outside, but is not required. Storage cabinets with approved flame arresters may be exhausted through a fume hood

---

---

exhaust system. If the storage cabinet is not vented, the bung must be in place.

11. The maximum storage allowed inside a flammable storage cabinet is 60 gallons of Class I or Class II liquids, nor more than 120 gallons of Class III liquids (see Table IV-2 for explanation of classification categories).
12. The maximum storage (per fire area) allowed outside of an approved flammable storage cabinet is as follows:
  - a. if not stored in safety cans, 10 gallons of Class I and Class II combined, or
  - b. if stored in safety cans, 25 gallons of Class I and II liquids combined, or
  - c. 60 gallons of Class IIIA liquids (see Table IV-2).
13. No more than three flammable storage cabinets may be located in a single fire area.
14. Class I liquids (see Table IV-2) may not be stored in basement areas. Class II and IIIA liquids may be stored in basements provided that automatic sprinkler protection and other fire protection facilities are provided.
15. Flammable solids are not specifically addressed by OSHA or NFPA regulations, but should always be kept in a flammable storage cabinet when not in use.
16. Additional guidelines which apply to central storage locations include:
  - a. Storage must be physically secure.
  - b. Storage rooms or cages must be equipped with spill control/containment typically adequate for 10% of the storage capacity or the volume of the largest container.
  - c. Metal drums used for storage and dispensing must be grounded properly.
  - d. NFPA labeling is recommended on the outside of storage room doors at approximately waist level or lower to allow adequate visualization in dense smoke conditions.

Sources: OSHA Flammable and Combustible Liquids Standard (29 CFR 1910.106)  
OSHA Occupational Exposure to Hazardous Chemicals in Laboratories Standard (29 CFR 1910.1450)  
NFPA 30, Flammable and Combustible Liquids  
NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals

TABLE IV-2 CLASSIFICATION CATEGORIES AND CONTAINER REQUIREMENTS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS						
	Flammable Liquids			Combustible Liquids		
	Class IA	Class IB	Class IC	Class II	Class IIIA	Class IIIB
Flash Point	<73°F (22.8°C)	<73°F (22.8°C)	≥73°F (22.8°C)	≥100°F (37.8°C) <140°F (60°C)	>140°F (60°C)	>200°F (93.3°C)
Boiling Point	<100°F (37.8°C)	≥100°F (37.8°C)	<100°F (37.8°C)	N/A	N/A	N/A
Maximum Container Size						
Glass or approved plastic	1 pt*	1 qt*	1 gal	1 gal	1 gal	1 gal
Metal (not DOT drums)	1 gal	5 gal	5 gal	5 gal	5 gal	5 gal
Safety cans	2 gal	5 gal	5 gal	5 gal	5 gal	5 gal
Metal drum (DOT)	60 gal	60 gal	60 gal	60 gal	60 gal	60 gal
Approved portable tanks	660 gal	660 gal	660 gal	660 gal	660 gal	660 gal

\*Exception: glass or plastic containers of no more than 1-gallon capacity may be used for a Class IA or IB flammable liquid if:

(a) such liquid either would be rendered unfit for its intended use or required liquid purity would be affected by contact with metal or would excessively corrode a metal container so as to create a leakage hazard; and the user's process either would require more than 1 pint of a Class IA liquid or more than 1 quart of a Class IB liquid of a single assay lot to be used at one time, or would require the maintenance of an analytical standard liquid of a quality which is not met by the specified standards of liquids available, and the quantity of the analytical standard liquid required to be used in any one control process exceeds 1/16th the capacity of the container allowed under Table IV-1 for the class of liquid; or

(b) the containers are intended for direct export outside the United States.

N/A=Not applicable