American University of Beirut

Laboratory Safety Manual

Environmental Heath, Safety & Risk Management

Life Safety & Hygiene Division

APRIL 2006

Forward.

The American university of Beirut (Campus, Medical Center, & AREC) is committed to providing its patients, students, employees and visitors with an environmental health, safety and risk management services that support the university's mission of rendering education, research, patient care and public services.

The Life Safety and Hygiene Division of the Environmental Health, Safety & Risk Management (EHS&RM) is responsible for implementing the University's Policy on Environmental Health, Safety and Risk Management by ensuring that campus operations comply with Lebanese and/or US National Safety and environmental regulations, requirements and standards.

The purpose of this manual is to follow basic general laboratory safety rules in laboratories handling chemicals and other hazardous materials to establish a reasonable level of safety and property protection from the hazards created in a laboratory setting.

Important Phone Numbers.

Environmental Health, Safety & Risk Management:	2360
Safety/Environmental Engineer:	2361
Health Physics Services:	2360/2363
Fire Protection Engineer:	2360/2368
Occupational Safety Officer:	2360/2345
Protection Office:	2400
Fire:	5555
Beirut Fire Brigade:	175
Civil Defense:	125
Red Cross:	140

Table of Contents

Environmental Health, Safety, & Risk Management

GENERAL LABORATORY SAFETY
Chemical Hygiene Plan

1. POLICY

The American University of Beirut (AUB), comprised of the Campus, AUBMC, and AREC, is committed to provide a safe and healthy working environment for its students, staff, faculty, and the general public.

To minimize the potential exposure to hazardous materials AUB requires its students, staff, and faculty to adhere to basic General Laboratory Safety Rules in laboratories handling chemicals and other hazardous materials.

2. INTRODUCTION

The Occupational Safety and Health Administration's (OSHA) laboratory health standard (Occupational Exposures to Hazardous Chemicals in Laboratories (CFR 1910.1450)) requires employers of laboratory employees to implement exposure control programs and convey chemical health and safety information to laboratory occupants with hazardous materials. Specific provisions of the standard require:

1. chemical fume hood evaluations;
2. establishment of standard operating procedures for routine and "high hazard" laboratory operations;
3. research protocol safety reviews;
4. employee exposure assessments;
5. medical consultations/exams;
6. employee training;
7. labeling of chemical containers; and,
8. the management of chemical safety information sheets (Material Safety Data Sheets) and other safety reference materials.

The standard's intent is to ensure that laboratory employees are apprised of the hazards of chemicals in their work area, and that appropriate work practices and procedures are

in place to protect laboratory employees/occupants from chemical health and safety hazards.

The standard operating procedures (laboratory practices and engineering controls) recommended in this manual identify the safeguards that should be taken when working with hazardous materials. These safeguards will protect laboratory workers from unsafe conditions in the vast majority of situations. There are instances, however, when the physical and chemical properties, the proposed use, the quantity used for a particular purpose or the toxicity of a substance will be such that either additional, or fewer, controls might be appropriate to protect the laboratory worker. Professional judgment is essential in the interpretation of these standard operating procedures, and individual laboratories may modify these procedures to meet their specific uses and operational needs.

3. RESPONSIBILITY FOR SAFETY

It is the responsibility all lab occupants (students, faculty, staff, and visitors) to follow the "Policy on Environmental Health, Safety, and Risk Management". Each individual is responsible for conducting activities in a manner that will not endanger himself/herself or any others. Any difficulty in performing procedures safely is to be reported to the immediate supervisor. Individuals are also expected to take an active part in correcting and reporting hazards.

Supervisors and Principal Investigators are to implement all possible measures to provide a safe working environment for those under their direction and to instruct them in safe work procedures. Situations requiring further assistance should be reported to the Department Head.

Department Heads, Chairs and Deans are responsible for overseeing the application of health and safety programs by ensuring that supervisory personnel reporting to them assume their responsibilities for adhering to safety regulations and guidelines. They are also required to identify those situations requiring further assistance or intervention (eg. from the EHSRM).

3.1. CHEMICAL HYGIENE RESPONSIBILITIES

Responsibility for chemical health and safety rests at all levels including the:

President of the University, who has ultimate responsibility for chemical hygiene within the University and must, along with other officials, provide continuing support for chemical safety.

Environmental Health, Safety, and Risk Management

A. Responsibility:

Environmental Health, Safety, and Risk Management (EHSRM) is in charge with the responsibility for control, review, monitoring and advice with respect to exposure to chemical, and other hazardous materials used in research and teaching. EHSRM provides oversight and control of physical hazards in the workplace, including general and laboratory safety, and chemical waste disposal.

B. Authority:

EHSRM has the authority to stop any activity which is immediately hazardous to life or health. Its primary function however, is to act in an advisory capacity to the individual departments, and to help them provide a safe and healthy workplace.

C. Resources:

EHSRM has professional staff who can be called upon for advice and help on safety and environmental health problems. This staff offers the following services relating to chemical hygiene for the University:

Evaluate and implement safety policies and review new and existing equipment and operating practices to minimize hazards to the University community and visitors from fire, electricity, hazardous materials, explosion, pressure and machinery.

Conduct accident investigations and suggest remedial measures and procedures.

Hazardous waste disposal services are provided for chemical and other hazardous materials.

Training and assistance in safe chemical handling and other health and safety topics

All members of the University should feel free to consult with EHSRM involving exposure from potential toxic chemical or other hazardous materials.

EHSRM services are available both in emergency situations and in an advisory capacity to answer questions from anyone at the University. However, procedures for safe use and disposal of chemicals start in the laboratory; therefore students, technicians must be informed about their responsibilities and the procedures to be followed by the principal investigator.

In the event of an emergency situation, please call EHSRM at ext. 2360.

The Environmental and safety Engineer oversees and manages chemical hygiene for the entire University. These duties are as follows:

Develop and implement University wide components of the Chemical Hygiene Plan to ensure consistent and well documented program procedures and policy decisions. University wide components will typically exclude specific departmental components such as laboratory standard operating procedures, training schedules, and other responsibilities given to department Safety Officers/laboratory supervisors.

Work with department chairs or department Safety officers/laboratory supervisors to develop specific components of the Chemical Hygiene Plan. Special attention will be given to the safe procurement, use, and disposal of chemicals.

Assist department Safety officers/laboratory supervisors with conducting training sessions for all laboratory workers including supervisors, faculty, principal investigators, teaching assistants, students, visiting scholars, etc.

Assist department Safety officers/laboratory supervisors with required safety audits and the documentation (record keeping) of audits and all employee training sessions.

Advise department Safety officer/laboratory supervisors on implementation of all components of the Chemical Hygiene Plan and any specific concerns regarding the appropriate use of audits and all employee training sessions.

4. DEFINITIONS

4.1. LABORATORY DEFINITION

For the purposes of this OSHA standard a laboratory is defined as a facility in which hazardous chemicals (defined below) are handled or manipulated in reactions, transfers, etc. in small quantities (containers that are easily manipulated by one person) on a non-production basis. Typically, multiple chemical procedures are used.

Hazardous Chemical Definition

The OSHA Laboratory Health Standard defines a hazardous chemical as any element, chemical compound, or mixture of elements and/or compounds which is a physical or a health hazard. The standard applies to all hazardous chemicals regardless of the quantity.

A chemical is a physical hazard if there is scientifically valid evidence that it is a combustible liquid, a compressed gas, an explosive, an organic peroxide, an oxidizer or pyrophoric, flammable, or reactive.

A chemical is a health hazard if there is statistically significant evidence; based on at least one study conducted in accordance with established scientific principles; that acute or

chronic health effects may occur in exposed employees. Classes of health hazards include:

* carcinogens
* reproductive toxins
* sensitizers
* hepatotoxins (liver)
* agents that act on the hematopoietic system (blood)
* agents that damage the lungs, skin, eyes, or mucus membranes
* irritants
* corrosives
* neurotoxins (nerve)
* nephrotoxins (kidney)

A chemical is considered a carcinogen or potential carcinogen. if it is listed in any of the following publications (OSHA uses the term "select" carcinogen):
National Toxicology Program, Annual Report on Carcinogens (latest edition)
International Agency for Research on Cancer, Monographs (latest edition)
OSHA, 29 CFR 1910.1001 to 1910.1101, Toxic and Hazardous Substances
A chemical is considered hazardous, according to the OSHA standard, if it is listed in any of the following:
OSHA, 29 CFR 1910.1000 Table Z-1 through Z-3
Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, ACGIH (latest edition)
The Registry of Toxic Effects of Chemical Substances, NIOSH (latest edition)
Over 600,000 chemicals are considered hazardous by the OSHA definition.
In most cases, the chemical container's original label will indicate if the chemical is hazardous. Look for key words like caution, hazardous, toxic, dangerous, corrosive, irritant, carcinogen, etc. Containers of hazardous chemicals acquired or manufactured before 1985 may not contain appropriate hazard warnings.
If you are not sure a chemical you are using is hazardous, review the Material Safety Data Sheet for the substance or contact your supervisor.

5. BASIC RULES, REGULATIONS AND PROCEDURES

5.1. DO's

1. Wear lab coats (knee-length) and appropriate eye protection (minimum safety goggles).
2. Keep clean work places free of unwanted chemicals, biological specimens, radios, and idle equipment.
3. Keep exits and passageways clear at all time.
4. Become familiar with the locations and operation of safety and emergency facilities such as the fire extinguishers, first aid kit, emergency wash facilities, fire alarm pull stations, telephone, and emergency exits.
5. Wash hands before leaving the laboratory.
6. Leave behind protective clothing (lab coats, gloves, etc.) When leaving the laboratory to eat.
7. Remove contaminated cloths immediately
8. Wash before eating, drinking, smoking, or applying make-up
9. Tie or otherwise restrain long hair when working with chemicals, biohazards, radioisotopes, or moving machinery.
10. Work only with materials when you know their flammability, reactivity, toxicity, safe handling, storage and properly operating emergency procedures.
11. Perform all procedures involving the liberation of volatile materials or aerosols of a toxic or flammable nature in a fume hood.
12. Place sharp objects (syringe needles, broken glass, blades, etc.) In a labeled rigid container before disposal. Materials contaminated with bio-hazardous agents should first be autoclaved.
13. Keep wet hands and water away from electrical equipment.
14. Secure your compressed cylinders.
15. Perform a safety check at the end of each experiment - make sure that gas, water, electricity, vacuum lines, air and heaters have been turned off and decontaminate any equipment or work areas which may have been in contact with hazardous materials.
16. Lock laboratory when unoccupied.
17. Store coats, packs, etc., in areas provided, not around the lab bench.

18. Pay strict attention to all instructions before undertaking an experiment. If you do not understand, ask.
19. Clean up apparatus and work areas at the end of the lab period.
20. Set up apparatus so that it is not necessary to reach through the assembly to turn water, gas or electricity off.
21. Assemble apparatus so that control valves and switches will remain accessible if a fire should occur.
22. Be aware of what neighboring laboratory personnel are doing.

5.2. DO NOT'S

1. Wear open shoes, such as sandals, in the lab.
2. Block access to emergency equipment (eyewashes, safety showers and fire extinguishers).
3. Pipette by mouth.
4. Pour water into acid
5. Return unused chemicals to stock bottles.
6. Run, walk in the lab.
7. Carry hazardous chemicals between the lab and storage rooms by hand. Use secondary containers.
8. Place chemicals where they will cause trip hazards, or are liable to cause personal injury. Reagent bottles, empty or full should not be left on the floor.
9. Place chemicals near incompatible substances that may cause them to react.
10. Leave chemicals or experiments unattended.
11. Store food, food containers, drinking glasses in the laboratory.
12. Keep food in refrigerators at the laboratory.
13. Sniff or taste chemicals.
14. Smoke, eat, or drink, food, beverages or tobacco in laboratories.
15. Apply cosmetics or lip-balm in the laboratory.
16. Engage in horseplay or other act or mischief in the lab.
17. Perform unauthorized experiments.
18. Remove chemicals from the lab unless directed otherwise from the instructor/supervisor.
19. Use damaged or broken equipment when handling or experimenting with chemicals.

6. GOOD WORK PRACTICES/PROCEDURES FOR HANDLING LABORATORY CHEMICALS

6.1. GENERAL GUIDELINES

Carefully read the label before using a chemical. The manufacturer's or supplier's Material Safety Data Sheet (MSDS) will provide special handling information. Be aware of the potential hazards existing in the laboratory and the appropriate safety precautions. Know the location and proper use of emergency equipment, the appropriate procedures for responding to emergencies, and the proper methods for storage, transport and disposal of chemicals within the facility.

Do not work alone in the laboratory. If you must work alone or in the evening, let someone else know and have them periodically check on you.

Anyone considering running an experiment unattended should consider the possible hazards that could occur as a result of failures, malfunctions, operational methods, environments encountered, maintenance error and operator error.

Label all secondary chemical containers with appropriate identification and hazard information.

Use only those chemicals for which you have the appropriate exposure controls (such as a chemical fume hood) and administrative programs/procedures (training, restricted access, etc.). Always use adequate ventilation with chemicals. Operations using large quantities (500 milliliters) of volatile substances with workplace standards (TLV) at or below 50 ppm should be performed in a chemical fume hood.

Use hazardous chemicals and all laboratory equipment only as directed or for their intended purpose.

Inspect equipment or apparatus for damage before adding a hazardous chemical. Do not use damaged equipment.

Inspect personal protective apparel and equipment for integrity or proper functioning before use.

Malfunctioning laboratory equipment (hood) should be labeled or tagged "out of service" so that others will not inadvertently use it before repairs are made.

Handle and store laboratory glassware with care. Do not use damaged glassware. Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals or fragments should implosion occur.

Do not purchase or dispense more of a hazardous chemical than is needed for immediate use.

6.2. WHEN NOT PROCEED WITHOUT REVIEWING SAFETY PROCEDURES

Sometimes laboratory workers should not proceed with what seems to be a familiar task. Hazards may exist that are not fully recognized. Certain indicators (procedural changes) should cause the employee to stop and review the safety aspects of their procedure. These indicators include:

A new procedure, process or test, even if it is very similar to older practices.

A change or substitution of any of the ingredient chemicals in a procedure.

A substantial change in the amount of chemicals used (scale up of experimental procedures); usually, one should review safety practices if the volume of chemicals used increases by 200%.

A failure of any of the equipment used in the process, especially safeguards such as chemical hoods.

Unexpected experimental results (such as a pressure increase, increased reaction rates, unanticipated byproducts). When an experimental result is different from the predicted, a review of how the new result impacts safety practices should be made.

Chemical odors, illness in the laboratory staff that may be related to chemical exposure or other indicators of a failure in engineered safeguards.

The occurrence of any of these conditions should cause the laboratory employee to pause, evaluate the safety implications of these changes or results, make changes as necessary and proceed cautiously.

6.3. HANDLING GLASSWARE

Laboratory glassware is fragile and must be handled properly to avoid injury.

tubing should be broken as follows:

Scratch with a single stoke of a triangular file.

Moisten scratch and wrap a towel around the glass to protect hands. Place thumbnails against tubing opposite scratch and press while pulling apart. Fire polish ends before using.

When fire polish or bending glass tubing, place hot glass on wire gauze. Make sure glass is cool before touching it or handling to another person.

Choose a stopper with hole size appropriate to the size of the tubing. Lubricate the tubing and the hole with glycerin or water and wrap tubing in a towel to protect hands

incase the tubing should break. Grasp tubing close to point of insertion and apply force while slowly twisting tube. Hold stopper between thumb and forefinger and keep palm of hand away from the area where glass will come through stopper.

Apparatus that can roll such as thermometers should be placed on the lab bench braced against other objects at right angles to the edge of the bench, to keep them from rolling onto the floor.

Filter flasks used in vacuum filtration should be heavy walled and free from cracks or other imperfections. Vacuum must be released from all parts of apparatus before disconnecting

Broken glass should be swept with a brush and dustpan taking care to get all the fragments.

7. PROTECTIVE CLOTHING AND LABORATORY SAFETY EQUIPMENT

7.1. GENERAL CONSIDERATION

Personal protective clothing and equipment should be selected carefully and used in situations where engineering and administrative controls cannot be used or while such controls are being established. These devices are viewed as less protective than other controls because they rely heavily on each employee's work practices and training to be effective. The engineering and administrative controls which should always be considered first when reducing or eliminating exposures to hazardous chemicals include:

1. Substitution of a less hazardous substance
2. Scaling down size of experiment
3. Substitution of less hazardous equipment or process (e.g., safety cans for glass bottles)
4. Isolation of the operator or the process
5. Local and general ventilation (e.g., use of fume hoods)

The Material Safety Data Sheet (MSDS) will list the personal protective equipment (PPE) recommended for use with the chemical. The MSDS addresses worst case conditions. Therefore, all the equipment shown may not be necessary for a specific laboratory scale task.

Your supervisor, other sections of this manual or the Environmental and Safety Engineer can assist you in determining which personal protective devices are required for each

task. Remember, there is no harm in being overprotected. Appropriate personal protective equipment will be provided to employees.

7.2. PROTECTION OF SKIN AND BODY

Skin and body protection involves wearing protective clothing over all parts of the body, which could become contaminated with hazardous chemicals. Personal protective equipment (PPE) should be selected on a task basis, and checked to ensure it is in good condition prior to use (e.g., no pinholes in gloves).

7.3. NORMAL CLOTHING WORN IN THE LABORATORY

Where there is no immediate danger to the skin from contact with a hazardous chemical it is still prudent to select clothing to minimize exposed skin surfaces. Employees should wear long sleeved/long legged clothing and avoid short sleeved shirts, short trousers or skirts. A laboratory coat should be worn over street clothes and be laundered regularly. A laboratory coat is intended to prevent contact with dirt, chemical dusts and minor chemical splashes or spills. If it becomes contaminated, it should be removed immediately and the affected skin surface washed thoroughly. Shoes should be worn in the laboratory at all times. Sandals and perforated shoes are not appropriate. In addition, long hair and loose clothing should be confined.

7.4. PROTECTIVE CLOTHING

Additional protective clothing may be required for some types of procedures or with specific substances (such as when carcinogens, cryogens or large quantities of corrosives, oxidizing agents or organic solvents are handled). This clothing may include impermeable aprons, face shield and gloves as well as plastic coated coveralls, shoe covers, and arm sleeves. Protective sleeves should always be considered when wearing an apron. These garments can either be washable or disposable in nature. They should never be worn outside the laboratory. The choice of garment depends on the degree of protection required and the areas of the body, which may become contaminated. Rubberized aprons, plastic coated coveralls, shoe covers, and arm sleeves offer much greater resistance to permeation by chemicals than laboratory coats and, therefore, provide additional time to react (remove the garment and wash affected area) if contaminated.

For work where contamination is possible, special attention must be given to sealing all openings in the clothing. Tape can be utilized for this purpose. In these instances caps should be worn to protect hair and scalp from contamination.

7.5. GLOVES

Chemical resistant and special gloves should be worn whenever the potential for contact with corrosive, cryogen or toxic substances and substances of unknown toxicity exists. Gloves should be selected on the basis of the materials being handled, the particular hazard involved, and their suitability for the operation being conducted. Before each use, gloves should be checked for integrity. Gloves should be washed prior to removal whenever possible to prevent skin contamination. Non-disposable gloves should be replaced periodically, depending on frequency of use and their resistance to the substances handled.

Protective garments are not equally effective for every hazardous chemical. Some chemicals will "break through" the garment in a very short time. Therefore, garment and glove selection is based on the specific chemical utilized. General selection criteria is as follows:

GLOVE TYPE SELECTION GUIDE					
CHEMICAL FAMILY	BUTYL RUBBER	NEOPRENE	PVC (VINYL)	NITRILE	NATURAL LATEX
Acetates	G	NR	NR	NR	NR
Acids, inorganic	G	E	E	E	E
Acids, organic	E	E	E	E	E
Acetonitrile, Acrylonitrile	G	E	G	S	E
Alcohols	E	E	NR	E	E
Aldehydes	E	G	NR	S*	NR
Amines	S	NR	NR	F	NR
Bases, inorganic	E	E	E	E	E
Ethers	G	F	NR	E	NR
Halogens (liquids)	G	NR	F	E	NR

Inks	G	E	E	S	F
Ketones	E	G	NR	NR	G
Nitro compounds (Nitrobenzene, Nitromethane)	G	NR	NR	NR	NR
Oleic Acid	E	E	F	E	NR
Phenols	E	E	NR	NR	G
Quinones	NR	E	G	E	E
Solvents, Aliphatic	NR	NR	F	G	NR
Solvents, Aromatic	NR	NR	F	F	NR

*Not recommended for Acetaldehyde, use Butyl Rubber S - Superior E - Excellent G - Good F - Fair NR - Not Recommended

Contact the Environmental and Safety Engineer for personal protection equipment selection assistance or information.

7.6. EYE PROTECTION

It is required that every student, instructor and visitor in labs where experiments or demonstrations are being performed must wear industrial quality eye protective devices.

Approved eye protection devices for people handling chemicals must prevent both chemical splashes and flying particles (e.g. from broken glass) from entering the eye. The minimum eye protection device that meets these requirements is a goggle with hooded ventilation ports.

Safety glasses, goggles and goggles with face shield should be worn in the laboratory based upon the physical state, the operation or the level of toxicity of the chemical used. Safety glasses effectively protect the eye from solid materials (dusts and flying objects) but are less effective at protecting the eyes from chemical splash to the face. Goggles should be worn in situations where bulk quantities of chemicals are handled and chemical splashes to the face are possible. Goggles form a liquid-proof seal around the eyes, protecting them from a splash. When handling highly reactive substances or large

quantities of hazardous chemicals, corrosives, poisons and hot chemicals, goggles with face shield should be worn.

Contact lenses can increase the risk of eye injury if worn in the laboratory, particularly if they are of the gas permeable variety. Gases and vapors can be concentrated under such lenses and cause permanent eye damage. Chemical splashes to the eye can get behind all types of lenses. Once behind a lens the chemical is difficult to remove with a typical eye wash. For these reasons it is recommended that contact lenses not be worn in laboratories.

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

COMPARISON CHART -- EYE PROTECTION DEVICES									
TYPE	FRONT SPLASH Protection	SIDE SPLASH Protection	FRONT FLYING OBJECT IMPACT Protection	SIDE IMPACT Protection	NECK, FACE Protection	COMFORT TO WEARER	USER ACCEPTANCE	USE LIFETIME	COST
Goggles	Excellent	Excellent	Excellent	Excellent	Poor	Fair	Poor	Fair	Moderate
Glasses (no shields)	Good	Poor	Excellent	Poor	Poor	Good to very good	Very good	Very good	Moderate
Glasses (shields)	Good	Good	Good	Fair	Poor	Good	Good	Very good	Moderate
Face shield (various sizes)	Excellent	Good to excellent	Excellent (if adequate thickness)	Good to excellent	Depends on type and length	Fair	Good for short periods	Fair	Moderate (depending on type)

SOURCE: ANSI Z87.1(1989) Occupational and Educational Eye and Face Protection, available from American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018

7.7. PROTECTION OF THE RESPIRATORY SYSTEM

Inhalation hazards can be controlled using ventilation or respiratory protection. Check the label and MSDS for information on a substance's inhalation hazard and special ventilation requirements. When a potential inhalation hazard exists, a substance's label or MSDS contains warnings such as:

- Use with adequate ventilation - Avoid inhalation of vapors

- Use in a fume hood - Provide local ventilation

Take appropriate precautions before using these substances. Controlling inhalation exposures via engineering controls (ventilation) is always the preferred method. As with other personal protective equipment, respiratory protection relies heavily on employee work practices and training to be effective.

7.8. USE OF RESPIRATORS

Respirators are designed to protect against specific types of substances in limited concentration ranges. Respirators must be selected based on the specific type of hazard (toxic chemical, oxygen deficiency, etc.), the contaminant's anticipated airborne concentration, and required protection factors.

Types of respiratory protective equipment include:

1. Particle-removing air purifying respirators
2. Gas and vapor-removing air purifying respirators
3. Atmosphere supplying respirators

Respirators are not to be used except in conjunction with a medical and physical examination

8. CHEMICAL PROCUREMENT, DISTRIBUTION AND STORAGE

8.1. PROCUREMENT

Before a chemical is received, Material Safety Data Sheet (MSDS) including information about proper handling, disposal, protective equipment needs, etc. should be known and available to those who will be handling this chemical. Chemical containers shall be received intact and contain the proper labels (at least the name, hazard warning, & health effects) along with its MSDS. Because storage in laboratories is restricted to small containers, order small-container lots to avoid hazards associated with repackaging.

8.2. DISTRIBUTION

When chemicals are hand carried, the chemical container should be placed in secondary container or bucket. Rubberized buckets are commercially available and provide both

secondary containment as well as "bump" protection. If several bottles must be moved at once, the bottles should be transported on a small cart with a substantial rim to prevent slippage from the cart. Wherever available, a freight elevator should be used to transport chemicals from one floor to another.

8.3. STORAGE

Carefully read the label before storing a hazardous chemical. The MSDS will provide any special storage information as well as information on incompatibilities. Do not store un-segregated chemicals in alphabetical order. Do not store incompatible chemicals in close proximity to each other. Chemicals should be segregated in a separate area with local exhaust ventilation. Received chemicals shall be moved as soon as possible to the designated storage area. The storage area shall be illuminated, with storage maintained at or below eye level.

Chemicals shall be stored properly. Proper storage procedures are listed in table 1. hereafter.

Read the label carefully before storing a chemical. More detailed storage information is usually provided by the MSDS (Material Safety Data Sheet).

Ensure that incompatible chemicals are not stored in close proximity to each other.

Separate the following types of chemicals from each other according to the segregation scheme in Table1. Note that this is a simplified scheme and that in some instances chemicals of the same category may be incompatible. For more detailed information refer to the reactivity section of the Material Safety Data Sheet or a reference manual on reactive chemical hazards.

Use spill trays under containers of corrosive reagents.

Use National Fire Prevention Association (NFPA) or Underwriters Laboratories (UL) approved storage cabinets for flammable liquids.

Flammable chemicals that require refrigeration should be kept in "explosion safe" refrigerators.

Do not store hazardous liquids or large objects on shelves above eye level.

Use approved storage containers and safety cans for flammable liquids. It is preferable to store flammable chemicals in flammable storage cabinets. Flammable chemicals requiring refrigeration should be stored only in the refrigerators and freezers specifically designed for flammable storage.

A good place to store hazardous chemicals is a vented cabinet under the hood. Chemicals of different chemical classes can be segregated by placing them in trays. Do not store chemicals on bench tops or in hoods. Liquids (particularly corrosives or solvents) should not be stored above eye level.

Use secondary containers (one inside the other) for especially hazardous chemicals (carcinogens, etc.). Use spill trays under containers of strong reagents.

Avoid exposure of chemicals while in storage to heat sources (especially open flames) and direct sunlight.

Conduct annual inventories of chemicals stored in the laboratory and dispose of old or unwanted chemicals promptly in accordance with EHSRM's hazardous chemical waste program. Ensure that all containers are properly labeled.

8.4. CHEMICAL STORAGE - CHEMICAL STABILITY

Stability refers to the susceptibility of a chemical to dangerous decomposition. The label and MSDS will indicate if a chemical is unstable.

Many chemicals, most notably ethers, are susceptible to decomposition resulting in explosive products. Ethers, liquid paraffins, and olefins form peroxides on exposure to air and light. Since most of these products have been packaged in an air atmosphere, peroxides can form even if the containers have not been opened.

Unopened containers of ethers should be discarded after one year, unless the manufacturer added inhibitors. Containers of ethers should be discarded within six months of opening.. Ethers beyond their expiry dates should not be handled; for additional information on chemical stability, contact the Environmental and Safety Engineer or EHSRM @ ext. 2360 to arrange to have the material removed.

The storage scheme outlined above may not suffice to prevent mixing of incompatible chemicals. Certain hazardous combinations can occur even between chemicals of the same classifications. The following are common examples of incompatible combinations:

Table 1 - Suggested Segregation for Chemical Storage

INORGANIC Top	ORGANIC Top
Sulfur, phosphorous, arsenic, phosphorus pentoxide	Alcohols, glycols, etc.
Halides, sulfates, sulfites, thiosulfates, phosphates, etc.	Hydrocarbons, esters, etc.
Amides, nitrates (not ammonium nitrate), nitrites, etc.	Ethers, ketons, etc.
Metals & hydrides (store away from any water)	Epoxy compounds, isocyanates
Hydroxides, oxides, Silicates, etc.	Sulfides, polysulfides, etc.
Arsenates, cyanides, ets. (Store above acids)	Phenols, cresols
Sulfides, selenides, phosphides Carbides, nitrides	Peroxides, azides, etc.
Borates, chromates, manganates Permanganates, etc.	Acids, anhydrides, peracids, etc.
Chlorates, perchlorates, chlorites, Perchloric acid, peroxides, etc.	Miscellaneous
Acids, except nitric	Miscellaneous (Nitric acid)

8.5. INCOMPATIBLE CHEMICALS

Certain hazardous chemicals should not be mixed or stored with other chemicals because a severe reaction can take place or an extremely toxic reaction product can result. The label and MSDS will contain information on incompatibilities. The following represents a partial list of common incompatible chemicals (Reactive Hazards). Substances in the left hand column should be stored and handled so that they can not accidentally contact corresponding substances in the right hand column under uncontrolled conditions.

Table 2. Chemical Incompatibility

Acetic acid	Chromic acid, nitric acid, hydroxyl-containing compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetic anhydride	Hydroxyl containing compounds such as ethylene glycol, perchloric acid
Acetone	Concentrated nitric and sulfuric acid mixtures, hydrogen peroxide
Acetylene	Chlorine, bromine, copper, silver, fluorine, mercury
Alkali and alkaline earth metals, such as sodium, potassium, lithium, magnesium, calcium, and powdered aluminum	Carbon dioxide, Carbon tetrachloride, other chlorinated hydrocarbons (also prohibit the use of water, foam , and dry chemical extinguishers on fires involving these metals- dry sand should be employed)
Ammonia (anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrogen fluoride, any mineral acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organics, combustibles
Aniline	Nitric acid, hydrogen peroxide
Antimony pentasulfide (golden antimony sulfide)	Chlorates, nitrates, other oxidizing agents, acids
Bromine	Ammonia, acetylene, butadiene, butane, other petroleum gases, sodium carbide, turpentine, benzene, finely metals
Calcium hypochlorite	Acid, moisture
Calcium oxide	Water
Carbon, activated	Calcium hypochlorite, other oxidants
Chlorates (potassium chlorate)	Ammonium salts, acids, metal powders, sulfur, hypophosphites, finely divided organics, combustibles
Chlorine	Ammonia, acetylene, butadiene, butane, other petroleum gases, hydrogen, hydrocarbons, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, carbon monoxide, mercury, methane, phosphine, hydrogen sulfide
Chlorosulfonic acid	Water, metals

Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, glycerine, turpentine, alcohol, other flammable liquids
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or mineral)
Cyanide	Any acid, nitrates or nitrites, molten potassium, or sodium salts
Fluorine	Isolate from everything
Hydrazine	Hydrogen peroxide, nitric acid, any other oxidant
Hydrocarbons (benzene, butane, propane, gasoline, turpentine, etc.)	Fluorine, chlorine, bromine, chromic acid, peroxides
Hydrochloric acid	Nitric acid, chlorates, other oxidizing agents, common metals
Hydrocyanic acid	Nitric acid, alkalis
Hydrofluoric acid (anhydrous), Hydrogen fluoride	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, any flammable liquid, combustible materials, aniline, nitro-methane
Hydrogen sulfide	Fuming nitric acid, oxidizing gases, other oxidizing materials
Iodine	Acetylene, ammonia, (anhydrous or aqueous), hydrogen
Mercury	Acetylene, fulminic acid (produced in nitric acid ethanol mixtures), ammonia
Nitric acid (concentrated)	Acetic acid, acetone, alcohol, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, fulminates, picrates, chlorates, turpentine, carbides, metallic powders, nitritable substances
Nitroparaffins	Inorganic bases, amines
Oleum (fuming sulfuric acid)	Water
Oxalic acid	Silver and mercury and their salts
Oxygen	Oils, grease, hydrogen, flammable: liquids, solids, gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper,

	wood, grease, oils (all organics), any dehydrating agent
Peroxides, organic	Acids (organic or minerals), also avoid friction – store in cold place
Picric acid	Metals
Phosphorus (white)	Air, oxygen
Phosphorus pentoxide	Alcohol, strong bases, water
Potassium chlorate	Acids (see also chlorates)
Potassium perchlorate	Acids (see also perchlorates)
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid, alcohol, ethers, flammable gases, combustible materials
Silver and its salts	Acetylene, oxalic acid, tartaric acid, fulminic acid (produced in nitric acid ethanol mixtures), ammonia compounds, picric acid
Sodium	See alkali metals (above)
Sodium chlorite	Combustible materials, sulfur, acids
Sodium nitrite and nitrate	Ammonium nitrate and other ammonium salts
Sodium peroxide	Any oxidizable substance, such as ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfuric acid	Chlorates, perchlorates, permanganates, sulfides, nitrites, nitrates, fluorides, bromides, iodides, fulminates, metallic powders, carbides, picrates, other combustible materials
Sulfur	Chlorates, nitrates, other oxidizing materials
Titanium	DO NOT USE WATER, CARBON TETRACHLORIDE, FOAM OR DRY CHEMICAL ON TITANIUM FIRES
Zinc powder or dust	Acids, sodium hydroxide, potassium hydroxide
Zirconium	DO NOT USE WATER, CARBON TETRACHLORIDE, FOAM OR DRY CHEMICAL ON ZIRCONIUM FIRES

8.6. SPECIAL PRECAUTIONS AND CHEMICAL HANDLING PROCEDURE

Keep volatile chemicals covered wherever possible and work in the hood. Never put your nose directly over a container of volatile chemicals. To sample something by odor, direct some vapors towards the nose with the hand after filling the lung with air.
Handle dry ice and items stored in dry ice with tongs or insulating gloves.
Never put your head in a container of dry ice. Sudden suffocation may result.
Chemicals should be always rinsed off the outside of the bottle before returning it to the shelf.
Unlabeled chemicals must not be used. They should be identified and properly disposed.
Keep mercury out of sinks and sewer drains. Mercury spills must be reported and cleaned up immediately with a mercury spill kit (call EHSRM at ext. 2360).
Hydrofluoric acid must not be used except under direct supervision of the instructor. Immediate medical attention is necessary if this acid comes into contact with the body.

9. HEALTH AND SAFETY INFORMATION FOR WORK WITH CHEMICALS OF SPECIFIC HAZARD CLASS

9.1. FLAMMABLE LIQUIDS

Flammable liquids are among the most common of the hazardous materials found in laboratories. They are usually highly volatile (have high vapor pressures at room temperature) and their vapors, mixed with air at the appropriate ratio, can ignite and burn. By definition, the lowest temperature at which they can form an ignitable vapor/air mixture (the flash point) is less then 37.8 ºC (100oF) and for several common laboratory solvents (ether, acetone, toluene, acetaldehyde) the flash point is well below that. As with all solvents, their vapor pressure increases with temperature and, therefore, as temperatures increase they become more hazardous.
Control strategies for preventing ignition of flammable vapors include removing all sources of ignition or maintaining the concentration of flammable vapors below the lower flammability limit by using local exhaust ventilation such as a hood. The former strategy is more difficult because of the numerous ignition sources in laboratories. Ignition sources include open flames, hot surfaces, operation of electrical equipment and static electricity.
The concentrated vapors of flammable liquids are more dense than air and can travel away from a source a considerable distance (across laboratories, into hallways, down

elevator shafts or stairways). If the vapors reach a source of ignition, a flame can result that may flash back to the source of the vapor.

The danger of fire and explosion presented by flammable liquids can usually be eliminated or minimized by strict observance of safe handling, dispensing and storing procedures.

9.2. SPECIAL HANDLING PROCEDURES

While working with flammable liquids you should wear gloves, protective glasses, and a long sleeved lab coat. Wear goggles if dispensing solvents or performing an operation that could result in a splash to the face.

Large quantities of flammable liquids should be handled in a chemical fume hood or under some other type of local exhaust ventilation. 20 liter containers must be dispensed to smaller containers in a hood or under local exhaust ventilation. When dispensing flammable solvents into small storage containers, use metal or plastic containers or safety cans (avoid glass containers).

Make sure that metal surfaces or containers through which flammable substances are flowing are properly grounded, discharging static electricity. Free flowing liquids generate static electricity which can produce a spark and ignite the solvent.

Large quantities of flammable liquids must be handled in areas free of ignition sources (including spark emitting motors and equipment) using non-sparking tools. Remember that vapors are more dense than air and can travel to a distant source of ignition.

Never heat flammable substances by using an open flame. Instead, use any of the following heat sources: steam baths, water baths, oil baths, heating mantles or hot air baths.

Do not distill flammable substances under reduced pressure.

Store flammable substances away from ignition sources. The preferred storage location is in flammable storage cabinets. If no flammable storage cabinet is available, store these substances in a cabinet under the hood or bench. 2.5 liter containers or more should only be stored in a flammable storage cabinet. You can also keep the flammable liquids inside the hood for a short period of time. Storage in chemical fume hood is not preferred because it reduces hood performance by obstructing air flow.

The volume of flammable liquids dispensed in small containers (not including safety cans) in the open areas of laboratories should not exceed 10 gallons in most laboratories.

Never store glass containers of flammable liquids on the floor.

Oxidizing and corrosive materials should not be stored in close proximity to flammable liquids.

Flammable liquids should not be stored or chilled in domestic refrigerators and freezers but in units specifically designed for this purpose. It is acceptable to store or chill flammable in ultra-low temperature units.

10. HIGHLY REACTIVE CHEMICALS & HIGH ENERGY OXIDIZERS

10.1. GENERAL INFORMATION

Highly reactive chemicals include those, which are inherently unstable and susceptible to rapid decomposition as well as chemicals that under specific conditions, can react alone, or with other substances in a violent, uncontrolled manner, liberating heat, toxic gases, or leading to an explosion. Reaction rates almost always increase dramatically as the temperature increases. Therefore, if heat evolved from a reaction is not dissipated, the reaction can accelerate out of control and possibly result in injuries or costly accidents.

Air, light, heat, mechanical shock (when struck, vibrated or otherwise agitated), water and certain catalysts can cause decomposition of some highly reactive chemicals, and initiate an explosive reaction. Hydrogen and chlorine react explosively in the presence of light. Alkali metals, such as sodium, potassium and lithium, react violently with water, liberating hydrogen gas. Examples of shock sensitive materials include acetylides, azides, organic nitrates, nitro compounds, and many peroxides.

Organic peroxides are a special class of compounds that have unusual stability problems, making them among the most hazardous substances normally handled in laboratories. As a class, organic peroxides are low powered explosives. Organic peroxides are extremely sensitive to light, heat, shock, sparks, and other forms of accidental ignition, as well as to strong oxidizing and reducing materials. All organic peroxides are highly flammable.

Peroxide formers can form peroxides during storage and especially after exposure to the air (once opened). Peroxide forming substances include aldehydes, ethers (especially cyclic ethers), compounds containing benzylic hydrogen atoms, compounds containing the allylic structure (including most alkenes), vinyl and vinylidene compounds.

Examples of shock sensitive chemicals, a high energy oxidizers and substances which can form explosive peroxides are listed at the end of this section.

10.2. SPECIAL HANDLING PROCEDURES

Before working with a highly reactive material or a high energy oxidizer, review available reference literature to obtain specific safety information. The proposed reactions should be discussed with your supervisor. Always minimize the amount of material involved in the experiment; the smallest amount sufficient to achieve the desired result should be used. Scale-ups should be handled with great care, giving consideration to the reaction vessel size and cooling, heating, stirring and equilibration rates.

Excessive amounts of highly reactive compounds should not be purchased, synthesized, or stored in the laboratories. The key to safely handling reactive chemicals is to keep them isolated from the substances that initiate their violent reactions. Unused peroxides should not be returned to the original container.

Do not work alone. All operations where highly reactive and explosive chemicals are used should be performed during the normal work day or when other employees are available either in the same laboratory or in the immediate area.

Perform all manipulations of highly reactive or high energy oxidizers in a chemical fume hood. (Some factors to be considered in judging the adequacy of the hood include its size in relation to the reaction and required equipment, the ability to fully close the sash, and the composition of the sash.)

Make sure that the reaction equipment is properly secured. Use shields or guards, which are clamped or secured.

If possible, use remote controls for controlling the reaction (including cooling, heating and stirring controls). These should be located either outside the hood or at least outside the shield.

Handle shock sensitive substances gently, avoid friction, grinding and all forms of impact. Glass containers that have screw-cap lids or glass stoppers should not be used. Polyethylene bottles that have screw-cap lids may be used. Handle water-sensitive compounds away from water sources. Light-sensitive chemicals should be used in light-tight containers. Handle highly reactive chemicals away from the direct light, open flames and other sources of heat. Oxidizing agents should only be heated with fiberglass heating mantles or sand baths.

Refer to the label and the Material Safety Data Sheet to determine if a chemical is explosive.

Write the dates received and opened on all containers of explosive or shock-sensitive chemicals. Labels on peroxide forming substances should contain the date the container

was received, first opened and the initials of the person who first opened the container. Peroxide forming substances that have been opened for more than one year should be discarded. Never use a metal spatula with peroxides. Contamination by metals can lead to explosive decompositions.

When working with highly reactive compounds and high energy oxidizers, always wear the following personal protection equipment: lab coats, gloves and protective glasses/goggles. During the reaction, a face shield long enough to give throat protection should be worn.

Store highly reactive chemicals and high energy oxidizers in closed cabinets segregated from the materials with which they react and, if possible, in secondary containers. You can also store them in the cabinet under a hood. Do not store these substances above eye level or on open shelves.

Store peroxides and peroxide forming compounds at the lowest possible temperature. If you use a refrigerator, make sure it is appropriately designed for the storage of flammable substances. Store light-sensitive compounds in the light-tight containers. Store water-sensitive compounds away from water sources.

Shock sensitive materials should be discarded after one year if in a sealed container and within six months of opening unless an inhibitor was added by the manufacturer.

10.3. LIST OF SHOCK SENSITIVE CHEMICALS

Shock sensitive refers to the susceptibility of the chemical to rapidly decompose or explode when struck, vibrated or otherwise agitated. The following are examples of materials that can be shock sensitive:

The following are atomic groupings that are associated with the possibility of explosion:

acetylide	nitroso
hypohalite	diazonium
amine oxide	ozonide
nitrate	fulminate
azide	perchlorate
nitrite	N-haloamine
chlorate	peroxide
nitro	hydroperoxide
diazo	picrate

The following are common examples of materials known to be shock-sensitive and explosive:

ammonium perchlorate
ammonium nitrate
copper acetylide
dinitrotoluene
fulminate of mercury
lead azide
nitroglycerine
picric acid (when dry)
trinitrotoluene

List of High Energy Oxidizers

The following are examples of materials that are powerful oxidizing reagents:

Ammonium permaganate	Fluorine	Potassium perchlorate
Barium peroxide	Hydrogen peroxide	Potassium peroxide
Bromine	Magnesium perchlorate	Propyl nitrate
Calcium chlorate	Nitric acid	Sodium chlorate
Calcium hypochlorite	Nitrogen peroxide	Sodium chlorite
Chlorine trifluoride	Perchloric acid	Sodium perchlorate
Chromium anhydride or chromic acid	Potassium bromate	Sodium Peroxide

List of Peroxide Formers

The following are examples of the materials commonly used in laboratories which may form explosive peroxides:

Acetal	Dimethyl ether	Sodium amide
Cyclohexene	Dioxane	Tetrahydrofuran
Decahydronaphthalene	Divinyl acetylene	Tetrahydronaphthalene
Diacetylene	Ether (glyme)	Vinyl ethers
Dicyclopentadiene	Ethyleneglycol dimethyl ether	Vinylidene chloride
Diethyl ether	Isopropyl ether	
Diethylene glycol	Methyl acetylene	

10.4. PERCHLORIC ACID

This is a powerful oxidizing agent which may react explosively with reducing agents and organic matter. Perchloric acid vapors tend to condense on the insides of fume hoods and the inner linings of ducts, eventually forming perchlorate crystals which are shock-sensitive explosives. Many accidents, some of them fatal, involving the use of perchloric acid have been recorded.

Perchloric acid should only be used in a water wash down hood of non-combustible construction.

Do not perform perchloric acid digestions in an ordinary fume hood.

Organic materials should not be stored in a perchloric acid hood.

In wet digestions, organic matter should first be treated with nitric acid to destroy easily oxidizable matter.

Do not allow perchloric acid to come into contact with strong dehydrating agents (concentrated sulphuric acid, phosphorus pentoxide, etc.)

Anhydrous perchloric acid (greater than 85%) should be handled only by experienced research workers who are thoroughly familiar with its properties.

11. COMPRESSED GASES

11.1. GENERAL INFORMATION

Compressed gas cylinders contain gases or liquids at very high pressures reaching up to 1000 atmospheres. These cylinders should be handled as high-energy sources or potential explosives. Compressed gases are safe to work with if cylinders are handled properly and the gas dispensed according to established procedures. Compressed gases are unique in that they represent both a physical and a potential chemical hazard (depending on the particular gas). Gases contained in cylinders may be from any of the hazard classes described in this section (flammable, reactive, corrosive, or toxic). Because of their physical state (gaseous), concentrations in the laboratory can increase instantaneously if leaks develop at the regulator or piping systems, creating the potential for a toxic chemical exposure or a fire/explosion hazard. Often there is little or no indication that leaks have or are occurring. Finally, the large amount of potential energy resulting from compression of the gas makes a compressed gas cylinder a potential rocket or fragmentation bomb if the tank or valve is physically broken.

11.2. SPECIAL HANDLING PROCEDURES

The contents of any compressed gas cylinder should be clearly identified. No cylinder should be accepted for use that does not legibly identify its contents by name. All the cylinders must be marked on the body as to content.

Color coding is not a reliable means of identification and labels on caps have no value as caps are interchangeable.

Carefully read the label before using or storing a compressed gas. The MSDS will provide any special hazard information.

Transport gas cylinders in carts one or two at a time only while they are secured and capped. All gas cylinders should be capped and secured when stored. Use suitable racks, straps, chains or stands to support cylinders. All cylinders, full or empty, must be restrained and kept away from heat sources. Store as few cylinders as possible in your laboratory.

Always use the correct pressure regulator. Do not use a regulator adaptor.

All gas lines leading from a compressed gas supply should be clearly labeled identifying the gas and the laboratory served.

Place gas cylinders in such a way that the cylinder valve is accessible at all times. The main cylinder valve should be closed as soon as the gas flow is no longer needed. Do not store gas cylinders with pressure on the regulator. Use the wrenches or other tools

provided by the cylinder supplier to open a valve if available. In no case should pliers be used to open a cylinder valve.

Use soapy water to detect leaks. Leak test the regulator, piping system and other couplings after performing maintenance or modifications, which could affect the integrity of the system.

Oil or grease on the high pressure side of an oxygen cylinder can cause an explosion. Do not lubricate an oxygen regulator or use a fuel/gas regulator on an oxygen cylinder.

Never bleed a cylinder completely empty. Leave a slight pressure to keep contaminants out (172 kPa or 25 psi). Empty cylinders should not be refilled in laboratories unless they are equipped to prevent overfilling.

All gas cylinders should be clearly marked with appropriate tags indicating whether they are in use, full, or empty. Empty and full cylinders should not be stored in the same place. Cylinders must not be stored near sources of heat.

Cylinders of toxic, flammable or reactive gases should be purchased in the smallest quantity possible and stored/used in a fume hood or under local exhaust ventilation. If at all possible, avoid the purchase of lecture bottles. These cylinders are not returnable and it is extremely difficult and costly to dispose of them. Use the smallest returnable sized cylinder.

Oxidizing gases and reducing gases should be stored separately from each other.

Wear safety goggles when handling compressed gases that are irritants, corrosive or toxic.

An empty cylinder should be marked with the code "MT" and the date. The regulator should be removed, the valve cap replaced, and arrangement should be made to have it removed from the lab.

Never refill a cylinder

12. CORROSIVE CHEMICALS

12.1. GENERAL INFORMATION

The major classes of corrosive chemicals are strong acids and bases, dehydrating agents, and oxidizing agents. These chemicals can erode the skin and the respiratory epithelium and are particularly damaging to the eyes. Inhalation of vapors or mists of these substances can cause severe bronchial irritation. If your skin is exposed to a corrosive, flush the exposed area with water for at least fifteen minutes. Then seek medical treatment.

Strong acids. All concentrated acids can damage the skin and eyes and their burns are very painful. Nitric, chromic, and hydrofluoric acids are especially damaging because of the types of burns they inflict. Seek immediate medical treatment if you have been contaminated with these materials (particularly hydrofluoric acid).

Strong alkalis. The common bases used in the laboratories are potassium hydroxide, sodium hydroxide and ammonia. Burns from these materials are often less painful than acids. However, damage may be more severe than acid burns because the injured person, feeling little pain, often does not take immediate action and the material is allowed to penetrate into the tissue. Ammonia is a severe bronchial irritant and should always be used in a well-ventilated area, if possible in a hood.

Dehydrating agents. This group of chemicals includes concentrated sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide. Because much heat is evolved on mixing these substances with water, mixing must be done by adding the agent to water and not the reverse, to avoid violent reaction and spattering. Because of their affinity for water, these substances cause severe burns on contact with skin. Affected areas should be washed promptly with large volumes of water.

Oxidizing agents. In addition to their corrosive properties, powerful oxidizing agents, such as perchloric and chromic acids (sometimes used as cleaning solutions), present fire and explosion hazards on contact with organic compounds and other oxidizable substances. The hazards associated with the use of perchloric acid are especially severe. It should be handled only after thorough familiarization with recommended operating procedures.

12.2. SPECIAL HANDLING PROCEDURES

Corrosive chemicals should be used in the chemical fume hood and over plastic trays especially when handled in bulk quantities (> 1 liter) and when dispensing.

When working with bulk quantities of corrosives, wear gloves, face shields, laboratory coats and rubber aprons.

If you are handling bulk quantities on a regular basis, an eyewash should be immediately available and a shower close by. Spill materials - absorbent pillows, neutral absorbent materials or neutralizing materials (all commercially available) should be available in the laboratory.

Store corrosives in cabinets, under the hood or on low shelves, preferably in impervious trays to separate them physically from other groups of chemicals. Keep containers not in use in storage areas and off bench tops.

If it is necessary to move bulk quantities from one laboratory to another or from the stockroom, use a safety carrier (rubber bucket for secondary containment and protection of the container)

13. CHEMICALS OF HIGH ACUTE & CHRONIC TOXICITY

13.1. GENERAL INFORMATION

Substances that possess the characteristic of high acute toxicity can cause injury after a single or short term exposure. The immediate toxic effects to human health range from irritation to illness and death. Hydrogen cyanide, phosgene and nitrogen dioxide are examples of substances with high acute toxicity. The lethal oral doses for an average human adult of highly toxic substances range from one g to a few drops. Oral LD50 data for the rat or mouse is listed in the substance's MSDS. The LD50 toxicity test is usually the first toxicological test performed and is a good indicator of a substance's acute toxicity.

Substances that possess the characteristic of high chronic toxicity cause damage after repeated exposure or exposure over long periods of time. Health effects often do not become evident until after a long latency period - twenty to thirty years. Substances that are of high chronic toxicity may be toxic to specific organ systems - hepatotoxins, nephrotoxins, neurotoxins, toxic agents to the hematopoietic system and pulmonary tissue or carcinogens, reproductive toxins, mutagens, teratogens or sensitizers.

Specific acute and chronic toxicity information on the substances used in your laboratory can be found on these substances' MSDS. If you have additional questions, contact the Environmental and Safety Engineer.

13.2. SPECIAL HANDLING PROCEDURES

Avoid or minimize contact with these chemicals by any route of exposure. Protect the hands and forearms by wearing gloves and a laboratory coat. Rinse gloves with water prior to removing them.

Use these chemicals in a chemical fume hood or other appropriate containment device if the material is volatile or the procedure may generate aerosols. If a chemical fume hood is used, it should be evaluated to confirm that it is performing adequately (a face velocity of at least 100 linear feet per minute (±20%)) with the sash at the operating height.

Store volatile chemicals of high acute or chronic toxicity in the cabinet under the hood or other vented area. Volatile chemicals should be stored in unbreakable primary or secondary containers or placed in chemically resistant trays (to contain spills).

Nonvolatile chemicals should be stored in cabinets or in drawers. Do not store these chemicals on open shelves or counters.

Decontaminate working surfaces with wet paper towels after completing procedures. Place the towels in plastic bags and secure. Confirm disposal requirements with the Environmental and Safety Engineer.

Volatile chemicals should be transported between laboratories in durable outer containers.

Vacuum pumps used in procedures should be protected from contamination with scrubbers or filters.

Analytical instruments or other laboratory equipment generating vapors and/or aerosols during their operation, should be locally exhausted or vented in a chemical fume hood.

Skin surfaces that might be exposed to these substances during routine operations or foreseeable accidents should be covered with appropriate protective clothing. Gloves should be worn whenever transferring or handling these substances. Consider using full body protection (disposable coveralls) if the potential for extensive personal contamination exists.

All protective equipment should be removed when leaving the designated area and decontaminated (washed) or, if disposable, placed in a plastic bag and secured. Call the Environmental and Safety Engineer for disposal instructions. Skin surfaces - hands, forearms, face and neck - should be washed immediately.

Work surfaces on which these substances will be handled should be covered with an easily decontaminated surface (such as stainless steel) or protected from contamination with plastic trays or plastic backed paper.

Chemical wastes from procedures using these substances should be placed in containers and disposed of as hazardous chemical waste. The wastes should be stored in designated areas until picked up. If it is possible to safely chemically decontaminate all toxic substances to nontoxic materials during or at the end of the procedure, this should be done.

14. MAINTENANCE & INSPECTIONS

14.1. EYE WASH AND SAFETY SHOWERS

Eye wash fountains should be inspected and operated on weekly basis. Safety showers should be tested routinely on monthly basis, and other safety equipment (e.g. extinguishers) should be inspected regularly. All the maintenance and inspections of these equipment should be recorded in a log book at the department concerned

14.2. FUME HOODS

The performance standard for fume hoods at AUB is the delivery of a minimum face velocity of 100 linear feet per minute with a door opening of 30 cm (approximately half sash height). An anemometer is available from the EHSRM or Physical Plant to determine a fume hood's performance. EHSRM shall perform periodical inspection and evaluation of fume hoods at least twice per year.

To ensure your fume hood provides the highest degree of protection, observe the following guidelines:

1. Only materials being used in an ongoing experiment should be kept in the fume hood.
2. Cluttering of the hood will create airflow disturbances.
3. Large apparatus inside a hood should be placed on blocks or legs to allow air to flow underneath.
4. Operate the fume hood with the door as low as practical. Reducing the open face will increase the face velocity.
5. Work with your hands as far into the hood as possible. The contents should be at least 15 cm inside the hood.
6. Keep your head outside of the hood.
7. Avoid cross drafts at the face of the hood. Even pedestrian traffic may be sufficient current to cause air turbulence.
8. Keep fume hood door closed when not attended.

15. HAZARDOUS WASTE DISPOSAL PROGRAM

Laboratory hazardous "chemical" waste must be disposed of in accordance with EHSRM requirements. These waste management practices are designed to ensure maintenance of a safe and healthy environment for laboratory employees and the surrounding community without adversely affecting the environment. This will be accomplished through regular removal of hazardous waste and disposal of these wastes in compliance with all regulations and policies. Specific guidance on how to identify, handle, collect, segregate, store and dispose of chemical waste is available from the Hazardous Wastes Manual section of our Website or by contacting us directly.

Note that:

1. Hazardous waste must be disposed of in a timely manner.
2. Hazardous waste containers must be closed at all times during storage, except when waste is being added or removed.
3. All hazardous waste must be properly labeled at the time the waste is first placed in the container.
4. Hazardous waste should be accumulated in a designated storage area consistent with applicable regulations.
5. Hazardous waste regulations require separate training of personnel who generate or handle hazardous waste.
6. Never discharge wastes into the sewer unless you have contacted EHSRM ext. 2360 prior to disposal.
7. Generators of hazardous waste are required to incorporate waste minimization into any process that generates hazardous waste

15.1. WASTE MINIMIZATION

Although hazardous waste disposal services are not charged to the department directly, it is still a great financial burden to the University as a whole and drains funds that could be utilized elsewhere. Good management of hazardous materials will help minimize disposal costs and can be achieved by observing the following:

Label all materials: If the identity of a material is not known, it must be analyzed before disposal, the costs of which are prohibitive.

Do not overstock: One of the main sources of laboratory waste is surplus stock - the result of over-buying. It may be tempting to take advantage of lower unit prices by buying quantity, but costs of surplus chemical disposal may ultimately exceed any savings realized at the time of purchase.

Return test materials to their sources: If you are receiving pesticides, herbicides, or other test materials of a hazardous nature, ensure that the organizations supplying them accept responsibility for the disposal costs.

Do not accept donations of materials that you don't plan to use. Many companies have traditionally unloaded unwanted reagents by donating them to universities, who eventually absorb the costs of disposal.

Substitute hazardous experimental materials for non-hazardous ones. For example, use aqueous-based, biodegradable scintillation fluids whenever possible.

15.2. WASTE DISPOSAL

In general, no chemical waste should be disposed of into the sink, sewer, or regular trash container. Chemical wastes should be collected, labeled, dated, and disposed of through the EHSRM. Kindly refer to the Hazardous Materials Management Plan.

As a general rule in the lab, wastes should be disposed of as listed below. Check with your instructor for deviation from these guidelines.

1. Dry or solid chemicals should be disposed of in rigid containers
2. Paper should be disposed of in regular trash.
3. Aqueous wastes containing heavy metals or other toxic substances should be disposed of in bottles that can tightly hold liquids.
4. Acids and bases can be disposed down the sinks with running water. Common acids; hydrochloric, nitric, sulfuric, and acetic; may be neutralized or diluted to pH 6 and flushed down the sink. Common bases may be diluted to pH 8 or neutralized and flushed down the sink with running water.
5. Organic solvents should be separated in containers.

16. EMERGENCY PROCEEDURES

16.1. GENERAL INFORMATION

Try to anticipate the types of chemical spills that can occur in your laboratory and obtain the necessary equipment (spill kits and personal protective equipment) to respond to a minor spill. Learn how to clean up minor spills of the chemicals you use regularly safely. EHSRM will provide the necessary spill kits and training A MSDS contains special spill clean-up information and should also be consulted. Chemical spills should only be cleaned up by knowledgeable and experienced personnel.

If the spill is too large for you to handle, is a threat to health safety or the environment, or involves a highly toxic or reactive chemical, call for EHSRM assistance immediately

Hazardous Materials Emergencies

Chemical, biological and radioactive materials are present in laboratories. If a hazardous material is spilled or released the following precautions or actions are recommended, in addition, refer to "Hazardous Materials/Wastes Management Plan" for further action.

16.2. MAJOR CHEMICAL SPILL

Or If you are unsure about the danger of the material:

1. Attend to injured or contaminated persons and remove them from exposure.
2. Alert people in the laboratory to evacuate.
3. If spilled material is flammable, turn off ignition and heat sources. Place other device (plastic bag) over spilled material to keep substance from volatilizing.
4. Do not approach the spill and avoid contact with the material. Avoid breathing gases, fumes or smoke that may be generated. Vapours may be harmful even if there is no odour.
5. If others may be in danger, activate alarm or inform personnel to evacuate the area. Close doors to contain the area of the spill.
6. From a safe location call the EHSRM ext. 2360 (during working hours) or the Protection Office ext. 2400 (24 hours/day), describe the nature of the emergency.
7. Stay in a safe area near the vicinity so that you can assist emergency response personnel.

16.3. MINOR CHEMICAL SPILL

Or if you are certain that the spill or leak poses no immediate danger or personal injury report it as in 3 above and:

1. Alert people in immediate area of spill
2. Increase ventilation in area of spill (open windows, turn on hoods).
3. Wear personal protective equipment, including safety goggles, gloves and long-sleeve lab coat.
4. Avoid breathing vapors from spill.
5. Use absorbent material to keep the contamination from spreading or entering drains. Absorbents such as sand, vermiculite, towel papers etc. may be used.
6. Working from the outside-in absorb the spilled material and using a shovel or dust pan place the spilled material inside a plastic bag or container.
7. EHSRM personnel will advise on further actions.

If the spill is in a lab, shop or chemical storeroom:

1. Evacuate all personnel from the room.

2. Be sure hood/local exhaust is on.
3. If flammable liquids are spilled, disconnect the electricity to sources of ignition if possible.
4. Call EHSRM @ ext. 2360 to request additional assistance if you cannot manage the clean up yourself.

If spill is in a corridor or other public passageway:

1. Evacuate all people from the area.
2. Close off area to keep others out.
3. Call the EHSRM at ext. 2360.

16.4. BUTANE GAS LEAKS

All butane gas leaks should be considered as serious leaks and dealt with promptly.

1. Shut off gas source immediately.
2. Call EHSRM at ext. 2360 immediately.
3. Call Physical Plant (@ 2015 for Campus) or Plant Engineering (@6503 AUBMC) immediately.
4. Shut off all sources of ignitions (open flames, hot plates etc.)
5. Do not turn on or off the electricity.
6. Open windows for ventilation

16.5. SPILL RESPONSE

Principal investigators and academic professors are responsible to develop a contingency plan in response to the types of spill situations that may be anticipated for their operations. The following factors are to be considered when developing spill response procedures:

1. Categories of chemicals and their chemical, physical and toxicological (eg. oxidizers, flammable solvents) properties.
2. The quantities that may be released.
3. Possible locations of release (eg. laboratory, corridor).
4. Personal protective equipment needed.
5. Types and quantities of neutralizing or absorbing material needed.

6. The EHSRM will help principal investigators and academic professors in establishing their specific spill response plan.

These guidelines should be followed when initially responding to a spill situation:
Determine appropriate clean up method by referring to the Material Safety Data Sheet (MSDS). If you are unsure how to proceed, contact the EHSRM at ext. 2360 for advice or assistance. Do not attempt to clean up the spill if you do not have the necessary protective equipment.
If the spill is minor and of known limited danger, clean up immediately.
If the spill is of unknown composition, or potentially dangerous (explosive, toxic vapors), alert everyone present and evacuate the room.
If the spill cannot be safely handled using the equipment and personnel present, call the EHSRM at ext. 2360 (during working hours) or Protection Office at ext. 2400 (24 hours/day) to request assistance.

16.6. GUIDELINES FOR SPECIFIC TYPES OF SPILLS

Radioactive Spills
Response to radioactive spills shall be in accordance to the Radiation Protection Handbook of the University Radiation committee.

1. Personnel nearby must be notified to leave the immediate area, but remain as a group to be surveyed for contamination. Their movement must be confined to prevent the spread of radioactive material.
2. The spill must be covered with absorbent pads to contain the liquid.
3. Contact Health Physics Services at ext. 2360-63-67.
4. Involved personnel must remain nearby to ensure that no one enters the area and to be able to provide information when help arrives.
5. In the case where clothing might be contaminated, they must be removed and placed in plastic bags.
6. Contaminated skin must be GENTLY washed with soap and water. It is important that the integrity of the skin not to be damaged during washing.

Flammable and Toxic Liquids
If fire occurs, follow the IN CASE OF FIRE procedure.

If no flames are evident, pour adsorbent around the perimeter of the spill and then cover the rest of the material. Wear an appropriate respirator if toxic vapors are involved.
While wearing gloves resistant to the chemical being handled, scoop up the absorbed spill, place it in a plastic bag, seal it, and place in a labeled container.

Corrosives

A spilled corrosive solid (eg. phosphorous pentachloride, or aluminum chloride) should be blanketed with its neutralizing agent, swept up and placed into an open container, and then sprinkled into cold water inside of a fume hood. Shield against splattering.
Alert everyone present. If vapors are being released, clear the area.
Do not attempt to wipe up a corrosive liquid unless it is very dilute.
Gloves, boots, apron and eye protection MUST be used when neutralizing an extensive corrosive spill. Respiratory protection is required if the liquid releases corrosive vapor or gas.
Pour the required neutralizing or adsorbing material around the perimeter of the spill, then carefully add water and more neutralizing material to the contained area. Carefully agitate to promote neutralization.
Use pH paper to verify that all contaminated areas are neutralized and safe to wipe up.
If an adsorbent (eg. spill control pillows) is used instead of a neutralizer, scoop up the absorbed spill, place it in a plastic bag, seal it, and then place in a labeled box. If neutralized material contains no toxic heavy metals (eg. chromium), flush down the drain with plenty of water.

17. PERSONAL CONTAMINATION AND INJURY

17.1. GENERAL INFORMATION

All accidents, dangerous incidents (hazardous materials spills, etc.) or suspected occupational diseases should be reported using the Incident Report Form.
Forms should be completed within 24 hours of the incident and forwarded to the EHSRM.
All incidents, including those involving only minor injuries, "close calls" without injury, damage to equipment, chemical odors, or spills and leaks of hazardous materials should also be reported.

1. Know the locations of the nearest safety shower and eye wash fountain.

2. Report all incidents and injuries to your supervisor. Record all incident by filling the University incident report.
3. Do not move an injured person unless they are in further danger (from inhalation or skin exposure).
4. Get medical attention
5. Chemicals Spills on the Body
6. Quickly remove all contaminated clothing and footwear.
7. Immediately flood the affected body area with cold water for at least 15 minutes. Remove jewelry to facilitate removal of any residual material.
8. Wash off chemical with water only. Do not apply ointment. Do not use neutralizing chemicals, unguents, creams, lotions or salves.
9. Get medical attention promptly. Go to the Infirmary or the Emergency Room.

It should be noted that some chemicals (phenol, aniline,) are rapidly adsorbed through the skin. If a large enough area of skin is contaminated, an adverse health effect (systemic toxicological reaction) may occur immediately to several hours after initial exposure depending on the chemical, seek medical attention after washing the material off the skin. If the incident involves hydrofluoric acid (HF), seek immediate medical attention. Provide the physician with the chemical name.

17.2. CHEMICAL SPLASH IN THE EYE

1. Proceed to the eyewash immediately and activate it by pushing the lever forward.
2. Irrigate the eyeball and inner surface of eyelid with plenty of cool water for at least 15 minutes. Use eyewash or other water source. Forcibly hold eyelids open to ensure effective wash.
3. Get medical attention promptly. Go to Emergency Room.

17.3. INHALATION OF SMOKE, VAPORS AND FUMES

Anyone overcome with smoke or chemical vapors or fumes should be removed to uncontaminated air and treated for shock.

1. Do not enter the area if you expect that a life threatening condition still exists - oxygen depletion, explosive vapors or highly toxic gases (cyanide gas, hydrogen sulfide, nitrogen oxides, carbon monoxide)
2. If CPR certified, follow standard CPR protocols.
3. Get medical attention promptly. Transport to Emergency Room

17.4. BURNING CHEMICALS ON CLOTHING

1. Extinguish burning clothing by using the stop drop-and-roll technique; STOP (where you are), DROP (to the floor), and ROLL (to smother the flames); or by dousing with cold water, or use an emergency shower if it is immediately available.
2. Do not proceed to the shower until the flames have been extinguished. After the fire has been put out, go to the nearest shower or drench hose and cool the burned areas with water.
3. Remove contaminated clothing; however, avoid further damage to the burned area. If possible, send the clothing with the victim.
4. Remove heat with cool water or ice packs until tissue around burn feels normal to the touch.
5. Cover injured person to prevent shock.
6. Get medical attention promptly.

17.5. ACTIONS TO BE AVOIDED DURING EMERGENCIES

There are some actions which must not be taken when handling emergencies. These include:

1. Do not force any liquids into the mouth of an unconscious person.
2. Do not handle emergencies alone, especially without notifying someone that the accident has occurred.
3. Do not stay at the accident scene if you are not one of the emergency responders.

17.6. CUTS

1. Apply pressure to the cut with a sterile pressure dressing except when there is an object protruding from the wound, in which case apply pressure around the wound.
2. Obtain medical assistance for even small cuts, as infection may develop if not treated properly. Go to Emergency Room.

17.7. ANIMAL BITES

Immediately after treating wound (see CUTS, above), seek medical attention.

18. FIRE AND FIRE RELATED EMERGENCIES

If you discover a fire or fire-related emergency such as abnormal heating of material, a flammable gas leak, a flammable liquid spill, smoke, or odor of burning, immediately follow these procedures:

Provide EHSRM or Emergency Response Team with the details of the problem upon their arrival. Special hazard information you might know is essential for the safety of the emergency responders.

18.1. IN CASE OF FIRE

1. Remain calm – Do not shout "Fire".
2. Rescue: Rescue personnel who are in immediate danger. This step is usually performed simultaneously with step 3 Alarm.
3. Alarm: Give the alarm – Dial 5555 and inform operator of exact location of fire.
4. Contain: Close doors and windows to isolate fire and smoke from rest of the building.
5. Evacuate: Evacuate the building using the nearest exit (Do not use elevators). Do not reenter the building until the alarm is silenced and you are told that it is safe to reenter.
6. Extinguish: You may fight the fire if you have been trained to do so, your exit is assured and that the alarm has been given.

Once the Emergency Response Team or the Beirut Fire Brigade arrive, they will be in charge until they declare the area safe and leave the scene

18.2. FIRE ALARMS RINGING IN YOUR BUILDING

1. You must evacuate the building and stay out until notified to return.
2. Go to your designated assembly area if available, or move up-wind from the building and stay clear of driveways, sidewalks and other access ways to the building.
3. If you are a supervisor, try to account for your employees, keep them together and report any missing persons to the emergency personnel at the scene.

19. TRAINING & INFORMATION

19.1. CHEMICAL SAFETY TRAINING

All faculty, staff, and graduate students who work in any laboratory where hazardous chemicals are stored or used must complete the required safety awareness programs appropriate for the operations conducted in that laboratory. As a minimum, all personnel must complete the Safe Chemical Handling raining program offered through EHSRM. The Chairperson of Departments who deal or work with chemicals is responsible to ensure that all laboratory personnel complete the required training.

When an employee is to perform a non-routine task presenting hazards for which he or she has not already been trained, the employee's supervisor will be responsible for discussing with the employee the hazards of the task and any special measures (e.g., personal protective equipment or engineering controls) that should be used to protect the employee.

Every laboratory worker should know the location and proper use of needed or necessary protective clothing and equipment, and emergency equipment/procedures.

19.2. MATERIAL SAFETY DATA SHEETS

A Material Safety Data Sheet, often referred to by its acronym MSDS, is a detailed informational document prepared by the manufacturer or importer of a hazardous chemical that describes the physical and chemical properties of the product. Information included in a Material Safety Data Sheet aids in the selection of safe products, helps employers and employees understand the potential health and physical hazards of a chemical and describes how to respond effectively to exposure situations. Material Safety Data Sheets can be accessed through EHSRM Web Site. All laboratory personnel within a research group must be able to access this site or they will be required to keep hard copies of MSDS's for each chemical they use or store in the laboratory.

The format of a Material Safety Data Sheet may vary but there is specific information that must be included in each sheet. It is useful to review this information to increase your ability to use a Material Safety Data Sheet.

All Material Safety Data Sheets should include the following information:

Section I of the MSDS lists information identifying the manufacturer and the product.

1. Manufacturer's name, address and telephone number
2. Number to call in case of emergency involving product
3. Chemical name and synonyms

4. Trade name and synonyms
5. Chemical family and formula
6. CAS number (Chemical Abstract Service) for pure materials

Section II describes the various hazardous ingredients contained in the product, the percentages, and exposure limits when appropriate. All hazardous chemicals that comprise 1% or greater of the mixture will be identified. Carcinogens will be listed if their concentrations are 0.1% or greater. If a component is not listed, it has been judged to be non-hazardous or is considered proprietary information by the manufacturer. The types of components that might be listed include:

Pigments, catalysts, vehicles, solvents, additives, others

Base metals, alloys, metallic coatings, fillers, hazardous mixtures of other liquids, solids or gases.

Section III describes the physical properties of the material.

- Boiling point
- Specific gravity
- Vapor pressure
- Percent volatile
- Vapor density
- Evaporation rate
- Solubility in water
- Appearance and odor

Section IV describes the fire and explosion hazard data for the material. Based on the flash point and other fire and explosion data, the appropriate extinguishing agent for fires involving the material will be listed. Special procedures may also be listed.

1. Flash point
2. Lower and upper explosive limits (LEL/UEL)
3. Extinguishing agent - water, dry chemical, foam, halon, etc.
4. Unusual fire and explosion hazards, toxic fumes

Section V describes the known health hazards associated with the material, applicable exposure limits and symptoms/health effects associated with overexposure. This information will help the user and medical personnel recognize if an overexposure has occurred.

1. Threshold Limit Value
2. Effects of overexposure: headache, nausea, narcosis, irritation, weakness, etc.
3. Primary routes of exposure: inhalation, skin, ingestion
4. Cancer or other special health hazards

5. Emergency and first aid procedures for ingestion, inhalation and skin or eye contact

Section VI describes reactivity data; that is, the material's ability to react and release energy or heat under certain conditions or when it comes in contact with certain substances.

1. Stability: stable, unstable, conditions to avoid
2. Incompatibility: materials to avoid
3. Hazardous decomposition products
4. Hazardous polymerizations: conditions to avoid

Section VII gives instructions for the steps to be taken in case of an accidental release or spill. The steps normally include information on containment, evacuation procedures and waste disposal as appropriate.

1. Steps to be taken in case material is released or spilled
2. Waste disposal methods

Section VIII describes the protective equipment for the individual who might have to work with the substance. This section normally describes worst case conditions; therefore, the extent to which personal protective equipment is required is task dependent. Contact your supervisor or Environmental and Safety Engineer for specific instructions if you are unsure.

1. Respiratory equipment: dust mask, chemical cartridge respirator, self-contained breathing apparatus
2. Ventilation: local, general, special
3. Protective gloves: type, fabrication material
4. Eye protection: goggles, face shield
5. Other protective equipment

Section IX describes handling and storage procedures to be taken with the material. Information may include statements, such as: keep container closed; store in a cool, dry, well ventilated area, keep refrigerated (caution: flammable solvents require a "flammable storage refrigerator"), avoid exposure to sunlight, etc.

Section X describes any special precautions or miscellaneous information regarding the material.

20. CHEMICAL TOXICOLOGY OVERVIEW

20.1. DEFINITIONS

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

Toxicity is the ability of a chemical substance or compound to produce injury once it reaches a susceptible site in, or on, the body.

A material's hazard potential is the probability that injury will occur after consideration of the conditions under which the substance is used.

4.1.2 Dose-Response Relationships

The potential toxicity (harmful action) inherent in a substance is exhibited only when that substance comes in contact with a living biological system. The potential toxic effect increases as the exposure increases. All chemicals will exhibit a toxic effect given a large enough dose. The toxic potency of a chemical is thus ultimately defined by the dose (the amount) of the chemical that will produce a specific response in a specific biological system.

20.2. ROUTES OF ENTRY INTO THE BODY

There are three main routes by which hazardous chemicals enter the body:

1. Absorption through the respiratory tract via inhalation.
2. Absorption through the skin via dermal contact.
3. Absorption through the digestive tract via ingestion. (Ingestion can occur through eating, drinking or smoking with contaminated hands or in contaminated work areas.)

Most exposure standards, such as the Threshold Limit Values (TLV's) and Permissible Exposure Limits (PEL's), are based on the inhalation route of exposure. These limits are normally expressed in terms of either parts per million (ppm) or milligrams per cubic meter (mg/m3) concentration in air. If a significant route of exposure to a substance is through skin contact, the MSDS, PEL and/or TLV will have a "skin" notation. Examples of substances where skin absorption may be a significant factor include: pesticides, carbon disulfide, carbon tetrachloride, dioxane, mercury, thallium compounds, xylene and hydrogen cyanide.

TLV: The threshold limit value is a recommended occupational exposure guideline published by the American Conference of Governmental Industrial Hygienists. TLV's are expressed as parts of vapor or gas per million parts of air by volume (ppm) or as approximate milligrams of particulate per cubic meter or air (mg/M3). The TLV is the average concentration of a chemical that most people can be exposed to for a working

lifetime with no ill effects. The TLV is an advisory guideline. If applicable, a ceiling concentration (C) that should not be exceeded or a skin absorption notation (S) will be indicated with the TLV.

PEL: The permissible exposure limit is a legal standard issued by OSHA. Unless specified, the PEL is a time weighted average (TWA).

TWA: Most exposure standards are based on time weighted averages. The TWA is the average exposure over an eight (8) hour work day. Some substances have Ceiling (C) limits. Ceiling limits are concentrations that should never be exceeded.

The MSDS will list the occupational health standard(s) for the hazardous chemical or each component of a mixture

20.3. TYPES OF TOXIC EFFECTS

1. **Acute** poisoning is characterized by sudden and severe exposure and rapid absorption of the substance. Normally, a single large exposure is involved. Adverse health effects are sometimes reversible. Examples: carbon monoxide or cyanide poisoning.
2. **Chronic** poisoning is characterized by prolonged or repeated exposures of a duration measured in days, months or years. Symptoms may not be immediately apparent. Health effects are often irreversible. Examples: lead or mercury poisoning.
3. A **Local** effect refers to an adverse health effect that takes place at the point or area of contact. The site may be skin, mucous membranes, the respiratory tract, gastrointestinal system, eyes, etc. Absorption does not necessarily occur. Examples: strong acids or alkalis.
4. A **Systemic** effect refers to an adverse health effect that takes place at a location distant from the body's initial point of contact and presupposes absorption has taken place. Examples: arsenic affects the blood, nervous system, liver, kidneys and skin; benzene affects bone marrow.
5. **Cumulative** poisons are characterized by materials that tend to build up in the body as a result of numerous chronic exposures. The effects are not seen until a critical body burden is reached. Example: heavy metals.
6. **Substances in combination**: When two or more hazardous materials are present at the same time, the resulting effect can be greater than the effect predicted based on the additive effect of the individual substances. This is called

a synergistic or potentiating effect. Example: exposure to alcohol and chlorinated solvents; or smoking and asbestos.

20.4. OTHER FACTORS AFFECTING TOXICITY

1. Rate of entry and route of exposure; that is, how fast is the toxic dose delivered and by what means.
2. Age can affect the capacity to repair tissue damage.
3. Previous exposure can lead to tolerance, increased sensitivity or make no difference.
4. State of health, physical condition and life style can affect the toxic response.
5. Pre-existing disease can result in increased sensitivity.
6. Environmental factors such as temperature and pressure.
7. Genetic predisposition and the sex of the exposed individual.

20.5. PHYSICAL CLASSIFICATIONS

Gas applies to a substance, which is in the gaseous state at room temperature and pressure.

A Vapor is the gaseous phase of a material, which is ordinarily a solid or a liquid at room temperature and pressure.

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

An aerosol is composed of solid or liquid particles of microscopic size dispersed in a gaseous medium.

The toxic potential of an aerosol is only partially described by its airborne concentration. For a proper assessment of the toxic hazard, the size of the aerosol's particles must be determined. A particle's size will determine if a particle will be deposited within the respiratory system and the location of deposition. Particles above 10 micrometers tend to deposit in the nose and other areas of the upper respiratory tract. Below 10 micrometers particles enter and are deposited in the lung. Very small particles (<0.2 micrometers) are generally not deposited but exhaled.

20.6. PHYSIOLOGICAL CLASSIFICATIONS

Irritants

Irritants are materials that cause inflammation of mucous membranes with which they come in contact. Inflammation of tissue results from exposure to concentrations far below those needed to cause corrosion. Examples include:

- Ammonia
- Alkaline dusts and mists
- Hydrogen chloride
- Hydrogen fluoride
- Halogens
- Ozone
- Phosgene
- Diethyl/dimethyl sulfate
- Nitrogen dioxide
- Phosphorus chlorides
- Arsenic trichloride

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

- Sulfur dioxide
- Acetic acid
- Formaldehyde
- Formic acid
- Sulfuric acid
- Acrolein
- Iodine

Long term exposure to irritants can result in increased mucous secretions and chronic bronchitis.

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

A secondary irritant's effect on mucous membranes is overshadowed by a systemic effect resulting from absorption. Examples include:

- Hydrogen sulfide
- Aromatic hydrocarbons

Asphyxiants

Asphyxiants have the ability to deprive tissue of oxygen.

Simple asphyxiants are inert gases that displace oxygen. Examples include:

- Nitrogen - Nitrous oxide

- Carbon dioxide - Hydrogen

- Helium

Chemical asphyxiants reduce the body's ability to absorb, transport, or utilize inhaled oxygen. They are often active at very low concentrations (a few ppm). Examples include:

- Carbon monoxide - Cyanides

Anesthetics

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

- Halogenated hydrocarbons - Alcohols

Hepatotoxic agents cause damage to the liver. Examples include:

- Carbon tetrachloride - Tetrachloroethane - Nitrosamines

Nephrotoxic agents damage the kidneys. Examples include:

- Halogenated hydrocarbons - Uranium compounds

Neurotoxic agents damage the nervous system. The nervous system is especially sensitive to organometallic compounds and certain sulfide compounds. Examples include:

- Trialkyl tin compounds - Tetraethyl lead

- Methyl mercury - Carbon disulfide

- Organic phosphorus insecticides - Thallium

- Manganese

Some toxic agents act on the blood or **hematopoietic** system. The blood cells can be affected directly or the bone marrow (which produces the blood cells) can be damaged. Examples include:

- Nitrites - Aniline - Toluidine

- Nitrobenzene - Benzene

There are toxic agents that produce damage of the **pulmonary** tissue (lungs) but not by immediate irritant action. Fibrotic changes can be caused by free silica and asbestos. Other dusts can cause a restrictive disease called pneumoconiosis. Examples include:

- Coal dust - Cotton dust - Wood dust

A **carcinogen** is an agent that can initiate or increase the proliferation of malignant neoplastic cells or the development of malignant or potentially malignant tumors.
Known human carcinogens include:

- Asbestos
- Alpha-napthylamine
- 3,3'-Dichlorobenzidine
- Vinyl chloride
- Ethylene oxide
- N-nitrosodimethylamine
- 4-nitrobiphenyl
- Methyl chloromethyl ether
- Bis-chloromethyl ether
- Inorganic arsenic
- 1,2-Dibromo-3-chloropropane (DBCP)
- Coal tar pitch volatiles

A **mutagen** interferes with the proper replication of genetic material (chromosome strands) in exposed cells. If germ cells are involved, the effect may be inherited and become part of the genetic pool passed onto future generations.
A **teratogen** (embryotoxic or fetotoxic agent) is an agent, which interferes with normal embryonic development without causing a lethal effect to the fetus or damage to the mother. Effects are not inherited. Examples include:

- Lead - Thalidomide

A **sensitizer** is a chemical, which can cause an allergic reaction in normal tissue after repeated exposure to the chemical. The reaction may be as mild as a rash (allergic dermatitis) or as serious as anaphylactic shock. Examples include:

- Epoxies
- Toluene diisocyanate
- Nickel compounds
- Chromium compounds
- Poison ivy
- Chlorinated hydrocarbons

20.7. SOME TARGET ORGAN EFFECTS

The following is a categorization of target organ effects that may occur from chemical exposure. Signs and symptoms of these effects and examples of chemicals which have been found to cause such effects are listed.

Toxins	Target organ effect	Signs and symptoms	Example chemicals
Hepatotoxins	Cause liver damage	Jaudice; liver enlargement	Nitrosamines, chloroform, toluene, perchloroethylene, cresol, dimethylsulfate
Nephrotoxins	Cause kidney damage	Edema; proteinuria	Halogenated hydrocarbons, uranium, chloroform, mercury, dimethylsulfate
Neurotoxins	Affect the nervous system	Narcosis; behavior changes; decreased muscle coordination	Mercury, carbon disulfide, benzene, carbon tetrachloride, lead, mercury, nitrobenzene
Hematopoietic toxins	Decrease blood function	Cyanosis; loss of consicousness	Carbon monoxide, cyanides, nitro-benzene, aniline, arsenic, benzene, toluene
Pulmonary toxins	Irritate or damage the lungs	Cough; tightness in chest, shortness of breath	Silica, asbestos, ozone, hydrogen sulfide, chromium, nickel, alcohols
Reproductive toxins	Affect the reproductive system	Birth defects; sterility	Lead, dibromodichloropropane
Skin hazards	Affect the dermal layer of the body	Defatting of skin; rashes; irritation	Ketones, chlorinated compounds, alcohols, nickel, phenol, tri-chloroethylene
Eye hazards	Affect the eye or vision	Conjunctivitis, corneal damage	Organic solvents, acids, cresol, quinones, hydroquinone, benzyl, chloride, butyl alcohol, bases