ARKANSAS STATE UNIVERSITY
GOVERNING PRINCIPLES FOR CHEMICAL SAFETY

Number: S-004 **Responsible Official: Provost**
Version: 01 **Adopted: 8/26/2009**

1.0 INTRODUCTION

Occupational Health and Safety Policies and Procedures provide the practical knowledge necessary to maintain a safe working environment for Arkansas State University's (ASU) faculty, staff, students, and ancillary staff who use hazardous chemicals in the conduct of research and teaching.

2.0 PURPOSE

The purpose of this document is to ensure safe laboratory practices and to comply with the Occupational Safety and Health Administration's law on laboratory safety. It is not intended to be, nor can it be, all-inclusive.

3.0 DEFINITIONS

Aerosol. 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 concentration in milligrams per cubic meter (mg/m3). For a proper assessment of the toxic hazard, the size of the aerosol's particles is important. Particles above l micrometer tend to deposit in the upper respiratory tract. Below l micrometer particles enter the lung. Very small particles (<0.2 m) are generally not deposited.

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

Asphyxiants. Asphyxiants have the ability the deprive tissue of oxygen.

Asphyxiants, Simple. Simple asphyxiants are inert gases that displace oxygen. Examples include: Nitrogen, Nitrous oxide, Carbon dioxide, Hydrogen, Helium

Asphyxiants, Chemical. Chemical asphyxiants have as their specific toxic action rendering the body incapable of utilizing an adequate oxygen supply. They are active at very low concentrations (few ppm). Examples include: Carbon monoxide, Cyanides

Carcinogen. Carcinogen commonly describes any agent that can initiate or speed the development of malignant or potentially malignant tumors, malignant neoplastic proliferation of cells, or that possesses such material. Known human carcinogens include: Asbestos, 4-Nitrobiphenyl, Alpha-napthylamine, Methyl cloromethyl ether, 3,3'-dichlorobenzidine, Bis-chloromethyl ether, Vinyl chloride, Inorganic arsenic, Ethylene oxide, 1,2-dibromo-3-chloropropane, N-nirosodimethylamine, (DBCP), Coal tar pitch volatiles. For additional information, reference the National Toxicology Program, *Annual Report of Carcinogens*, National Toxicology Program (latest edition), *Monographs*, International Agency for Research on Cancer, (latest edition), and *Toxic and Hazardous Substances*, OSHA, 29CFR1910, Subpart Z.

Chemicals as Hazardous Waste. A chemical is defined as a hazardous waste if it is one of the listed chemicals in 40 CFR Ch. I § 261.33, is corrosive (Ph > 12.5 or pH < 2.0), or is flammable (flash point > 140Ï F) or is reactive.

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

Hazardous Chemical (Substance). Any element, chemical compound, or mixture of elements or compounds, which is a physical hazard or a health hazard. (Source: Public Employees Right to Know Act) A Hazardous Chemical is also defined as a chemical listed in any of the following:

- OSHA, 29CFR1910, Subpart Z, "Toxic and Hazardous Substances"
- ACGIH, "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Place" (latest edition)
- NIOSH, "The Registry of Toxic Effects of Chemical Substances"

Hazardous Waste. A chemical is defined as a hazardous waste if it is one of the listed chemicals in 40 CFR Ch. I § 261.33, is corrosive (Ph > 12.5 or pH < 2.0), or is flammable (flash point > 140Ï F) or is reactive.

Health Hazard. A health hazard is defined as: a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Included are: toxic, highly toxic, carcinogens, irritants, reproductive toxins, corrosives, sensitizers, radioactive materials, neurotoxins (nerve), biohazards, heptotoxins (liver), nephrotoxins (kidney), agents that act on the hematopoietic system (blood), agents that damage the lungs, skin, eyes, or mucus membranes.

Irritants. Irritants are materials that cause inflammation of mucous membranes with which they come in contact. Inflammation of tissue results from concentrations far below those needed to cause corrosion. Long term exposure to irritants can result in increased mucous secretions, chronic bronchitis, or changes in the mechanics of respiration and lung function. Examples include: Ammonia, Alkaline dusts and mists, arsenic trichloride diethyl/dimethyl sulfate, hydrogen chloride, hydrogen fluoride, halogens, nitrogen dioxide, ozone, phosgene, phosphorus chlorides, sulfur dioxide, acetic acid, formaldehyde, formic acid, sulfuric acid, acrolein, iodine.

Irritant, Primary. A primary irritant has 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.

Irritant, Secondary. A secondary irritant's effect on mucous membranes is over-shadowed by a systemic effect resulting from absorption. Examples include: Hydrogen sulfide, Aromatic Hydrocarbons. Exposure to a secondary irritant can result in pulmonary edema, hemorrhage and tissue necrosis.

Material Safety Data Sheets (MSDS). A Material Safety Data Sheet (MSDS), prepared in accordance with OSHA Hazard Communications Standards, is a document that is repared by the manufacturer explaining the nature of the hazard and its safe handling.

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

Sensitizer. A sensitizer causes a substantial number of exposed workers to develop an allergic reaction in normal tissue after repeated exposure. The reaction may be as mild as a rash (contact dermatitis) or as serious as anaphylactic shock. Examples include: Epoxies, Nickel Compounds, Poison ivy, Toluene di-isocyanate, Chromium compounds, Chlorinated hydrocarbons.

Toxicity. Toxicity is the study of the nature and action of poisons. Specifically, it is the ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or the body.

Toxicity Hazard. Toxicity Hazard is the probability that injury will occur considering the manner in which the substance is used.

Vapor. 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.

4.0 APPLICABILITY

These Governing Principles pertain to all faculty, staff, students, or unaffiliated personnel who use hazardous chemicals in the teaching or research at ASU.

5.0 REGULATIONS

Carcinogens, U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, U.S. Government Printing Office, Washington, D.C., latest edition.

Documentation of the Threshold Limit Values for Substances in the Workroom Air and Supplemental Documentation, American Conference of Governmental Industrial Hygienist: Cincinnati, OH., (latest edition).

Fire Protection Guide on Hazardous Materials, 7th ed., National Fire Protection Association: Boston, MA.

The Hazard Communication Standard - A Guide Book, National Safety Council: Chicago, IL., 60611.

The Industrial Environment-Its Evaluation and Control, U.S. Department of Health, Education and Welfare, Public Health Service, NIOSH, U.S. Printing Office: Washington, DC., Stock Number 017-001-00296-4, 1973.

Industrial Ventilation, American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation: Lansing, MI., (latest edition).

Lewis, R. J., Ed. *Registry of Toxic Effects of Chemical Substances*, DHEW (NIOSH), Publ Microfiche issued quarterly.

NIOSH/OSHA Product Guide to Chemical Hazards, DHEW (NIOSH): Sept. 1978, Publ. No. 78-210.

OSHA Safety and Health Standards (29 CFR 1910), United States Department of Labor, OSHA, Government Printing Office: Washington, D.C., (latest edition).

Radiological Health Handbook, U.S.H.E.W., Public Health Service, F.D.A., Bureau of Radiological Health: Rockville, MD. 20852, available from U.S.G.P.O. Stock number 017-011-00043-0.

TLVs: Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, TLV Airborne Contaminants Committee, American Conference of Governmental Industrial Hygienists: Cincinnati, OH., (latest edition).

Zabetakis, M. G. *Flammable Characteristics of Combustible Gases and Vapors*, U.S. Bureau of Mines Bulletin 627, 1965

6.0 GOVERNING PRINCIPLES

Arkansas State University's policy is to provide a safe and healthy work environment and to prevent injury to personnel and loss or damage to property. *Chemical Safety* is an important component of that commitment, acquainting laboratory personnel with safety procedures when working with hazardous chemicals. Careful planning, training, and implementation of best practices are all important elements of any safety program,

yielding significant rewards in terms of injury prevention, creation of a healthy work environment, and research time saved.

6.1 EMPLOYEE RIGHTS

Employers are required to advise employees of their rights regarding the Chemical Right to Know Act. Employees who may be exposed to hazardous chemicals are guaranteed access to the following: Written Hazard Communication Program, workplace chemical lists, Material Safety Data Sheets (MSDS), and chemical exposure information. In addition, employees shall receive training on the hazards of chemicals and on the measures they can take to protect themselves from those hazards and must be provided with personal protective equipment as appropriate. Further, these Governing Principles and "Notices to Employees" are posted in various campus locations.

Alleged violations of the Act should be referred to one's supervisor, the Personnel Department, the Environmental Health & Compliance Department EH&C (2862) or directly to the Arkansas Department of Labor, (501) 682-4541.

An employee has a right to file a complaint against his/her employer regarding alleged violations of the Chemical Right to Know Act. If one files a complaint, the Act protects him from: discharge, cause for discharge, discipline, discrimination, loss of pay, position, seniority or benefits.

Providing hazardous chemical information does not negatively impact employee rights with regard to their health and/or safety. The employer in any case has responsibility for taking the necessary steps to prevent the occurrence of occupational disease and unnecessary exposure.

Exemptions[1] to the Public Employee Right to Know Act include:

- any article that does not release hazardous chemicals under normal use;
- products intended for personal consumption;
- any food, food additive, drug, cosmetic or distilled spirits, wines or malt beverages packaged for sale to consumers;
- foods, drugs, or cosmetics intended for personal consumption by employees while in the workplace;
- any consumer product or hazardous substance, as those terms are defined in the Consumer Product Safety Act (15 U.S.C. 2051 et seq.) and Federal Hazardous Substance Act (15 U.S.C. 1261 et seq.) respectively, where the employer can demonstrate it is used in the workplace in the same manner as normal consumer use, and which use results in a duration and frequency of exposure which is not greater than exposure experienced by consumers.

[1]If you are not sure a chemical in your work area is exempted, contact your supervisor or EH&C (2862).

-

6.2 TRAINING

New or newly-assigned employees must be provided training before working with or in a work area containing hazardous chemicals. Additional instruction is likewise required when: 1) the potential for exposure to hazardous chemicals is altered, or 2) new information concerning a chemical is received. Thereafter, at least annually, the University must provide refresher programs for employees who use or handle chemicals.

Training programs include the following elements where appropriate:

- Interpreting labels and MSDS[2];
- waste disposal;
- location of hazardous chemicals;
- clean-up procedures;
- personal protective equipment; and
- safe handling procedures;
- acute and chronic effects of chemicals.

The University may substitute generic training for chemical-specific training in the event that a large variety of hazardous chemicals are stored or in use. In those cases, supervisors are required to provide any additional training that may be necessary.

The University is required to maintain a record of training sessions that are conducted. You may be required to sign a ledger verifying your attendance at a training session.

If you do not understand the material provided or discussed, contact your supervisor or EHS (2862).

6.3 HAZARD LABELING SYSTEM

ASU uses the Hazardous Material Identification Guide (HMIG) for hazard labeling. Substances purchased after 1985 must be labeled to indicate whether the chemical is hazardous. A label is any written, printed, or graphic material displayed on or affixed to containers of hazardous materials. Labels must contain the contents of the container, name and address of the manufacturer, physical and health hazards and recommended personal protective equipment. Labeling such as **caution, hazardous, toxic, dangerous,**

[2] EHS (2862) is the central repository for all Material Safety Data Sheets (MSDSs). They are also located in department offices where hazardous chemicals are used or on- EHS web page. Additionally, the manufacturer or distributer must provide an appropriate MSDS for each chemical purchased. If an MSDS is not provided with a shipment of a chemical, a request for one must be sent to the supplier in a timely manner. The employer must assure the MSDSs on file are current. Upon request, the employer must make MSDSs available to employees or designated representatives. For a section-by-section review, please see Appendix A.

corrosive, irritant, carcinogen, suspect carcinogen, etc. also indicate the type of hazard.

Products purchased prior to 1985 may not have hazard warnings. In those cases, the University must affix an HMIG label (Please see Appendix B). Existing labels on containers of hazardous chemicals shall not be removed.

If a hazardous chemical is transferred from an original container to another container, a label shall be placed on the new container identifying the chemical and appropriate hazard warnings. If the chemical is regulated under the federal Insecticide, Fungicide, and Rodenticide Act, or the Arkansas Pesticide Control Act § 2-16-401 *et seq*., then the chemical name or common name on the original container must be placed on the new container.

Employees who transfer chemicals for immediate use are not required to label the containers. Nevertheless, employees are not allowed to work with a chemical in an unlabeled container they did not fill themselves.

Employees are required to real all label information carefully, request Material Safety Data Sheet (MSDS), or contact their supervisors if in doubt concerning the proper use of any hazardous chemicals.

7.0 RESPONSIBILITIES

Administrators. The implementation of these Governing Principles is the responsibility of the managerial and supervisory staff of the University. Vice Presidents, Deans, Chairpersons, Directors, Heads of Units, Laboratory Supervisors, Principal Investigators and all other supervisory personnel are accountable for the health and safety of employees engaged in activities under their supervision. This responsibility cannot be delegated. Supervisors must realize that it is their responsibility to ensure that workers are educated about safety issues and comply with safety rules. Supervisors must simultaneously promote safety and insist upon it.

Environmental Health and Safety (EHS). Environmental Health and Safety will assist supervisory personnel in establishing and maintaining a safe working environment. This department will initiate the establishment of standards and regulations for safety, education, information monitoring and recommendations for improvements. Environmental Health and Compliance will also maintain and provide facilities to ensure laboratory safety.

Laboratory Personnel. All laboratories must have:

- Primary Responsible Person (PRP), Department, Phone number (PRP), Emergency Phone number (PRP)
- General function of the lab (organic research, gen. chem., zoology, physical chem., instrumentation, etc.

- Chemical Inventory including location in lab and maximum quantity (an MSDS must be available for each chemical).
- Operational procedures for safe handling and appropriate disposal of hazardous chemicals (this may be by class and type of chemical).
- Hazards (flammable storage, water reactive chemicals, and extremely toxic materials) this is for firefighters and spill response.
- Items 1, 2 & 5 must be posted at each entrance. A copy of the SOP must be retained in departmental office as well as with EH&C.

APPENDIX A
MATERIAL SAFETY DATA SHEETS: SECTION BY SECTION

Section I: Chemical Product and Company Identification

- Links the MSDS to the material.
- Identifies the supplier of the MSDS.
- Identifies a source for more information, including emergency information, if available.

Section II: Composition and Information on Ingredients

- Lists the Occupational Safety & Health Administration hazardous components.
- May also list significant non-hazardous components.
- Lists corresponding Chemical Abstracts Registry Numbers, where appropriate, for each component.
- May include additional information, such as exposure guidelines, about components.

Section III: Hazards Identification

- Provides information on the potential adverse health effects and symptoms that might result from reasonably foreseeable use and misuse of the material.
- May provide an emergency overview that describes the material's appearance and severe, immediate health, physical, and environmental hazards associated with emergency response situations.

Section IV: First-Aid Measures

Provides easily understandable instructions on what to do when results of exposure require immediate treatment and when simple measures may be taken before professional medical assistance is available. Instructions provide for each route of exposure.

Section V: Fire-Fighting Measures

- Provides basic fire-fighting guidance, including appropriate extinguishing media.
- Describes other fire and explosive properties useful for fighting fires involving the material such as flash points, explosive limits.

Section VI: Accidental Release Measures

- Describes actions to be taken to minimize the adverse effects of an accidental spill, leak, or release of the material.

Section VII: Handling and Storage

- Provides information on appropriate practices for safe handling and storage of the material.

Section VIII: Exposure Controls Personal Protection

- Provides information on practices and/or equipment useful for minimizing worker exposure.
- Provides guidance on personal protection equipment.
- May also include exposure guidelines.

Section IX: Physical and Chemical Properties

- Identifies the physical and chemical properties that characterize the material.

Section X: Stability and Reactivity

- Describes the conditions that could result in a potentially hazardous chemical reaction.

Section XI: Toxicological Information:

- May be used to provide information on toxicity testing of the material and/or its components for medical professionals, occupational safety and health professionals and toxicologists.

Section XII: Ecological Information:

- May be used to provide information on the effects the material may have on plants, animals, and its environmental fate.

Section XIII: Disposal Considerations:

- May provide information useful to determine appropriate disposal measures.

Section XIV: Transportation Information:

- May provide basic shipping classification information.

Section XV: Regulatory information:

- May be used to provide information on state, federal, and international regulations affecting the material or its components.

Section XVI: Other Information.

APPENDIX B
PROTOCOL FOR LABELING HAZARDOUS CHEMICALS

This Appendix contains the tables that you will need to label hazardous chemicals appropriately. The HMIG label is where you will record the Health, Flammability, and Reactivity Index Ratings.

HMIG LABEL

CHEMICAL NAME	
HEALTH (BLUE)	
FLAMMABILITY (RED)	
REACTIVITY (YELLOW)	
PROTECTIVE EQUIPMENT	

HEALTH INDEX RATINGS

Level	Risk	Toxicity Characteristics
4	Extreme	• On very short exposure could cause death or major residual injury even though prompt medical treatment is given. • A known or suspected human carcinogen, a mutagen, or teratogen.
3	Serious	• May cause serious temporary or residual injury on short term exposure even though prompt medical attention is given. • A known or suspected small animal carcinogen, mutagen, or teratogen.
2	Moderate	• Intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.
1	Slight	• May cause irritation but only minor residual injury even without treatment. • Recognize innocuous materials when used with reasonable care.
0	Minimal	• No chemical is without some degree of toxicity.

FLAMMABILITY INDEX RATINGS

Level	Risk	Flammability Characteristics
4	Extreme	• Extremely flammable. Flash point below 73ºF (22.8 C)..
3	Serious	Flammable. Will have one or more of the following characteristics: • Vaporizes rapidly and can be ignited under almost all

		ambient conditions. • May form explosive mixtures with or burn rapidly in air. • May burn rapidly due to self-contained oxygen. • May ignite spontaneously in air. • Flash point at or above 73ºF (28.8 C) but less than 100ºF (37.8 C).
2	Moderate	Combustible. Will have one or more of the following characteristics: • Must be moderately heated or exposed to relatively high temperatures for ignition to occur. • Solids which readily give off flammable vapors. • Flash point at or above 100ºF (37.8 C) but less than 200ºF (93.4 C). • .
1	Slight	Slightly combustible. Will have one or more of the following characteristics: • Must be preheated for ignition to occur. • Will burn in air when exposed at 1500ºF (815.5 C) for five minutes. • Flash point at or above 200ºF (93.4 C).
0	Minimal	• Will not burn. • Will not exhibit a flash point. • Will not burn in air when exposed at 1500ºF (815.5 C) for five minutes.

REACTIVITY INDEX RATINGS

Level	**Risk**	**Reactivity Characteristics**
4	Extreme	• Can explode or decompose violently at normal temperature and pressure. • Can undergo a violent self-accelerating exothermic reaction with common materials or by itself. • May be sensitive to mechanical or local thermal shock at normal temperature and pressure.
3	Serious	• Can detonate or explode but requires a strong initiating or confined heating before initiation. • Readily promotes oxidation with combustible materials and may cause fires. • Is sensitive to thermal or mechanical shock at elevated temperatures. • May react explosively with water without requiring heat or confinement.

2	Moderate	• Normally unstable and readily undergoes violent change but does not detonate. • May undergo chemical change with rapid release of energy at normal temperature and pressure. • May undergo violent change at elevated temperature and pressure. • May react violently with water. • Forms potentially explosive mixtures with water..
1	Slight	• Normally stable material which can become unstable at high temperature and pressure. • May react with water to release energy but not violently.
0	Minimal	• Normally stable material which is not reactive with water.

The first (white) section of the HMIG is where the chemical or product name will be printed. The second (blue) section will have a number (0 to 4) indicating the health hazard rating. The third (red) section will have a number (0 to 4) indicating the flammability rating. The fourth (yellow) section will have a number (0 to 4) indicating the reactivity rating. The fifth (white) section will have an alphabetic character (a through k or x) indicating the protective equipment index.

The table indicates the indexes which are placed in the boxes on the right side of the HMIG labels. The numbers and alphabetic characters indicate the hazard or the protective equipment required. The picture next to the alphabetic character represents the PPE needed. The numbers indicate the hazard in ascending order from MINIMAL to EXTREME.

APPENDIX C
HEALTH HAZARDS

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

1. Absorption caused by inhalation through the RESPIRATORY TRACT. This may cause the most severe reactions.
2. Absorption through the SKIN. This is the most serious in development of occupational diseases; e.g., dermatitis.
3. Absorption through the DIGESTIVE TRACT. This can occur when eating or smoking with contaminated hands or in contaminated work areas.

Effects

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

Chronic Poisoning is characterized by prolonged or repeated exposures of a duration measured in days, months or years. Symptoms may not be immediately apparent. Examples: lead or mercury poisoning, pesticide exposure.

Local refers to the site of action of an agent and means the action takes place at the point or area of contact. The site may be skin, mucous membranes, the respiratory tract, gastro-intestinal system, eyes, etc. Absorption does not necessarily occur. Examples: strong acids or alkalis and war gases.

Systemic refers to a site of action other than the point of contact and the pre-supposes absorption has taken place. For example, an inhaled material may affect the liver; arsenic may affect the blood, nervous system, liver, kidneys and skin; and benzene may affect the bone marrow.

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

Substances in Combination: When two or more hazardous materials are present at the same time, the resulting effect can more serious than the effect predicted based on the individual substances. This is called a SYNERGISTIC or POTENTIATING EFFECT. An example is exposure to alcohol and chlorinated solvents.

Toxic Effect on Organs

Organs that may be affected by exposure to toxic chemicals include:

Hepatotoxics: Causes liver damage.
Signs and symptoms-Jaundice; liver enlargement
Example chemicals-Carbon tetrachloride, nitrosamines, chloroform, toluene, perchloro-ethylene, cresol, dimethylsulfate

Nephrotoxics: Produce kidney damage
Signs and symptoms-Edema; proteinuria
Example chemicals-Halogenated hydrocarbons, uranium, chloroform, mercury, dimethyl sulfate

Neurotoxins: Affect the nervous system
Signs and symptoms--Narcosis; behavioral changes; decreased muscle coordination.

Example chemicals-Mercury, carbon disulfide, benzene, carbon tetrachloride, lead, mercury, nitrobenzene

Hematopoietic Agents: Decreased blood function
Signs and symptoms--Cyanosis; loss of consciousness
Example chemicals--Carbon monoxide, cyanides, nitrobenzene, aniline, arsenic, benzene, toluene

Pulmonary Agents: Irritate or damage the lungs
Signs and symptoms--Cough; tightness in chest, shortness of breath
Example chemicals--Silica, asbestos, ozone, hydrogen sulfide, chromium, nickel, alcohols

Reproductive toxins: Affect the reproductive system (mutations and teratogenesis)
Signs and symptoms--Birth defects; sterility
Example chemicals--Lead, dibromo/dichloropropane

Skin hazards: Affect the dermal layer of the body
Signs and symptoms--De-fatting of skin; rashes; irritation
Example chemicals--Ketones, chlorinated compounds, alcohols, nickel, phenol, trichloroethylene

Eye hazards: Affect the eye or vision
Signs and symptoms--Conjunctivitis; Corneal damage
Example chemicals--Organic solvents, acids, cresol, quinone, hydroquinone, benzol chloride, butyl alcohol, bases

Hygienic Standards (See Glossary)

Chemical Toxicity

The potential toxicity (harmful action) inherent in a substance is manifest only when that substance comes in contact with a living biological system. A chemical normally thought

of as "harmless" will evoke a toxic response if added to a biological system in sufficient quantity. The toxic potency of a chemical is thus ultimately defined by the relationship between the dose (the amount) of the chemical and the response that is produced in a biological system.

Other factors affecting toxicity:

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

Inhalation Hazards

Respirators are designed to protect against specific types of substances and in certain concentration ranges. Respirator selection is based on the hazard and the protection factors required.

If your work requires the use of a respirator, you will receive special training from your supervisor and the Occupational Safety Department (3217). Respirators are not to be used except in conjunction with a complete respiratory protection program. Do not use respiratory protective equipment until you have received proper training.

Types of respiratory protective equipment include:

- Particle-removing air purifying respirators,
- Gas and vapor-removing air purifying respirators, and
- Atmosphere supplying respirators.

Be familiar with the limitations of each type of respiratory protective equipment used and the signals for respirator failure (odor breakthrough, filter clogging, etc.).

APPENDIX D
CHEMICAL STABILITY

Stability refers to the susceptibility of the chemical to dangerous decomposition. Ethers, liquid paraffins, and olefins form peroxides on exposure to air and light. Since these chemicals are packaged in an air atmosphere, peroxides can form even through the containers have not been opened.

- Unless an inhibitor was added by the manufacturer, closed containers of ethers should be discarded after 1 year.
- Open containers of ethers should be discarded within 6 months of opening.
- The label and MSDS will indicate if a chemical is unstable.
- The following are examples of materials which may form explosive peroxides:

Acetal	Cyclohexene	Decahydronapthalene	Diacetylene
Dicyclopentadiene	Diethyl ether	Diethylene glycol	Dimethyl ether
Dioxane	Divinyl acetylene	Ether (glyme)	Ethylene glycol
Isopropyl ether	Methyl acetylene	Sodium Amide	Tetrahydrofuran
Tetrahydronaphthalene	Vinylidene Chloride	Vinyl ethers	

APPENDIX E
COMPATIBILITY OF CHEMICALS ACCORDING TO HAZARD CLASS

The following outline can be used to segregate laboratory chemicals.
Chemical groups should be kept separate from each other.

Group A: Inorganic Acids and Related Compounds
Examples: Hydrochloric, Sulfuric, Nitric acids (>40%) etc.
Hazard: Corrosive

Group B: Alkalis, Bases, Amines
Examples: Caustic Soda, Potassium Hydroxide, Sodium Hydroxide, Ethanolamine
Hazard: Corrosive

Group C: Elements and Inorganic Salts, Carcinogens, Pesticides
Examples: Mercury, Lead, Aluminum Sulfate, Sodium Thiosulfate, Benzidine, Aldrin, Chlordane
Hazard: Poison

Group D: Organic Solvents
Examples: Aldehydes, Esters, Ketones, Hydrocarbons, Methanol, Acetaldehyde, Ethyl Ether, Acetone, Hexane, etc.
Hazard: Flammable or Combustible Liquids

Group E: Reactive Materials
Examples: Aluminum Hydroxide, Sodium Metal, Phosphorous, Pentoxide, Potassium Metal
Hazard: Flammable Solid, Corrosive

Group F: Organic Acids, Substituted Acids
Examples: Acetic Acid, Butyric Acid, Formic Acid, etc.
Hazard: Corrosive

Group G: Oxidizers
Examples: Ammonium Nitrate, Potassium Permanganate, Sodium Nitrate, Barium Chlorate
Hazard: Oxidizer

Group H: Peroxides
Examples: Benzyl Peroxide, Urea Peroxide, Peracetic Acid, Cummene Hyperoxide
Hazard:

Group I: Cyanides, Sulfides (Keep away from acids)
Examples: Potassium Cyanide, Potassium Sulfide, Hydrocyanic Acid, Allyl Cyanide
Hazard: Poison

APPENDIX F
INCOMPATIBLE CHEMICALS

Certain hazardous chemicals cannot be safely mixed or stored with other chemicals because a severe reaction can take place or an extremely toxic reaction product can result.

- The label and MSDS will contain information on incompatibilities.
- The following is a table containing examples of incompatible chemicals[3]:

Chemical	**Keep Out of Contact With:**
Acetic Acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali Metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, the halogens ammonia, anhydrous mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium Nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, fined divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Bromine	Same as chlorine
Carbon, Activated	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely-divided organic or combustible materials
Chromic Acid	Acetic acid, naphthalene, camphor, glycerine, turpentine, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium arbide, turpentine, benzene, finely divided metals
Chlorine Dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids, organic or inorganic
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic Acid	Nitric acid, alkali
Hydrofluoric acid	Ammonia, aqueous or anhydrous
Hydrogen	Copper, chromium, iron, most metals or their salts, alcohols,

[3] Manufacturing Chemists' Association, *Guide for Safety in The Chemical Laboratory*, pp. 215-217.

peroxide	acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing, gases
Hydrogen sulfide	Fuming nitric acid, oxidizing gases acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fluminic acid, ammonia
Nitric Acid	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Oxalic Acid	Silver, mercury
Perchloric Acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium permanganate	Glycerine, ethylene glycol, benzaldehyde, sulfuric acid
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium Peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide glycerine, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.

High-Energy Oxidizers:

Barium peroxide (BaO_2): combined with organic substances sensitive to friction, severe damage to respiratory sys.

Bromine (Br): highly reactive, serious tissue burns, toxic, serious damage to respiratory sys.

Calcium hypochlorite ($Ca[ClO]_2$): combined with flammables or organics easily ignited. Cl_2 evolved mixed with acids.

Chromium anhydride/Chromic acid (CrO_3): Ignites with acetic acid or alcohol. May ignite with other organics.

Hydrogen peroxide (H_2O_2): 35-50% ignites with organics, higher concentrations yield shock sensitive peroxides. Violently decomposes in contact with metals and salts, i.e. brass, bronze, Cr, Cu, Fe, Pb, Mn, Ag, etc.

Magnesium perchlorate ($Mg[ClO_4)_2$): Sensitive by heat or friction.

Nitric acid (HNO_3): explosive with carbides, H_2S, metallic powders, & turpentine. Severe burns to tissue.

Perchloric acid ($HClO_4$): very dangerous at high concentrations and temperatures.

Potassium bromate ($KBrO_3$): Moderate health haz. Ignites by heat or friction.
Potassium chlorate ($KClO_3$): Toxic and toxic fumes upon combustion. Ignites by heat or friction.
Potassium perchlorate ($KClO_4$): similar to Potassium chlorate.
Sodium perchlorate ($NaClO_4$): similar to Potassium perchlorate.
Sodium peroxide (Na_2O_2): reacts vigorously with water. Mixtures with, combustible, organic, or easily oxidizable materials are explosive. They ignite easily with heat, friction, or small quantities of water. Toxic if ingested.

APPENDIX G
SHOCK-SENSITIVE CHEMICALS

Shock-sensitive refers to the susceptibility of the chemical to rapidly decompose or explode when struck, vibrated or otherwise agitated.

- Some chemicals become increasingly shock sensitive with age. Write the date received and date opened on all containers of shock sensitive chemicals.
- Unless an inhibitor was added by the manufacturer, closed containers of shock sensitive materials should be discarded after 1 year.
- Open containers of shock sensitive materials should be discarded within 6 months of opening.
- The label and MSDS will indicate if a chemical is shock sensitive.
- Wear appropriate personal protective equipment when handling shock sensitive chemicals.
- The following are examples of materials which can be shock sensitive:

  Ammonium nitrate
  Calcium nitrate
  Dinitroethyleneurea
  Dinitrophenol
  Explosive mixtures
  Heavy metal azides
  Lead salts
  Nitrated carbohydrate
  Nitrated glucoside
  Nitrated polyhydric alcohol
  Nitroglycol
  Organic amine nitrates
  Organic nitramines
  Organic peroxides
  Picramic acid
  Picric acid
  Polynitro aliphatic
  Potassium
  Sodium nitrate
  Trinitrobenzene
  Trinitrobenzoic acid compounds

APPENDIX H
SOLVENTS

Many of the commonly used solvents are volatile and harmful when relatively small amounts are inhaled. Most are readily absorbed through the skin and most are flammable.

- Flammable liquids are more hazardous at elevated temperatures due to more rapid vaporization.
- Electrically ground and bond containers using approved methods before transferring or dispensing a flammable liquid from a large container or drum.
- Purchase only the amount necessary for immediate use.
- Use approved flammable liquid containers and storage cabinets.
- Keep flammable liquids from heat, flame, and direct sunlight.
- Do not store flammable liquids near oxidizing agents such as chromic acid, permanganates, chlorates or perchlorates.
- Avoid skin contact and inhalation of solvents.
- Use assigned personal protective equipment.
- Do not dispose of solvents down sinks or drains.
- Use with adequate ventilation or in a fume hood.
- Common solvents that are relatively toxic include:
  Aromatic hydrocarbons, especially benzene
  Esters of acetic or other organic acids
  Glycols, glycol esters and glycol ethers
  Halogenated hydrocarbons, Methyl alcohol
  Nitrogenous bases such as amines
  Carbon disulfide
- The label and MSDS will indicate any special hazards involving a solvent.

Appendix I
Segregation of Chemicals for Storage

SOLIDS	**LIQUIDS**	**GASES**
A. Oxidizers	A. Flammable	A. Toxic
B. Flammable	B. Others	B. Flammable
C. Water Reactive	1. Acids	C. Oxidizers & Others
D. All Others *	2. Caustics	
	3. Perchloric Acid	
	4. Oxidizers	

*Use Compatibility charts for segregation of others.

APPENDIX J

Chemicals ok to flush down the drain:		
Cation	**Cation**	**Anion**
Aluminum	Palladium	Bisulfite
Bismuth	Potassium	Bromate
Calcium	Rubidium	Bromide
Cerium	Scandium	Carbonate
Cesium	Strontium	Chloride
Copper	Tantalum	Cyanate
Gold	Tin	Hydroxide
Iron	Titanium	Iodide
Lanthides	Yttrium	Oxide
Lithium	Zinc	Phosphate
Magnesium	Zirconium	Sulfate
Molybdium (VI)		Sulfite
Niobium (V)		Thiocyanate

REFERENCES

1. Altman, P. L., Dittmer, D. S. Biology Data Book, Vol. I-III, 2nd ed., Fed. of Am. Societies for Experimental Biology: Bethesda, MD., 1972.
2. Anon. Toxic and Hazardous Industrial Chemicals Safety Manual, International Technical Information Institute: Tokyo, Japan, 1979.
3. Bretherick, L. Handbook of Reactive Chemical Hazards, 2nd ed., Butterworths: Boston, MA., 1979.
4. Brodsky, A., editor, CRC Handbook of Radiation Measurement and Protection, CRC Press Inc: West Palm Beach, FL., 1978.
5. Carcinogens, U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, U.S. Government Printing Office, Washington, D.C., latest edition.
6. Casarett, A. Radiation Biology, Prentice-Hall, Inc.: Englewood Cliffs, NJ., 1968.
7. Casarett, L. J., Doull, J., Eds., Toxicology, Macmillan: New York, 1975.
8. Cember, H. Introduction to Health Physics, Pergamon Press: New York, 1969.
9. Deichmann, W. B., Gerarde, H. W. Toxicology of Drugs and Chemicals, 4th ed., Academic Press: New York, 1969.
10. Delaware Code, Title 16, Chapter 24, "Hazardous Chemical Information Act", State of Delaware: Dover, Delaware.
11. Documentation of the Threshold Limit Values for Substances in the Workroom Air and Supplemental Documentation, American Conference of Governmental Industrial Hygienist: Cincinnati, OH., (latest edition).
12. Fire Protection Guide on Hazardous Materials, 7th ed., National Fire Protection Association: Boston, MA.
13. Goodman, L.S., Gilman, A., The Pharmacological Basis of Therapeutics, Macmillan: NY, 1975.
14. Gosselin, R. E., et al., Clinical Toxicology of Commerical Products: Acute Poisoning, 4th ed., Williams and Wilkins: Baltimore, 1976.
15. Green, M. E., Turk, A., Safety in Working with Chemicals, McMillan: New York, NY., 1978.
16. The Hazard Communication Standard - A Guide Book, National Safety Council: Chicago, IL., 60611.
17. Hilado, C. J., Clark, S. W., Autoignition Temperatures of Organic Solvents, Chem. Eng.: (NY), 1972, 79 (19), 75-80.
18. The Industrial Environment-Its Evaluation and Control, U.S. Department of Health, Education and Welfare, Public Health Service, NIOSH, U.S. Printing Office: Washington, DC., Stock Number 017-001-00296-4, 1973.
19. Industrial Ventilation, American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation: Lansing, MI., (latest edition).
20. Knoll, G., Radiation Detection and Measurement, John Wiley & Sons, NY, 1979.
21. Lewis, R. J., Ed. Registry of Toxic Effects of Chemical Substances, DHEW (NIOSH), Publ Microfiche issued quarterly.
22. Loomis, T. A. Essentials of Toxicology, 3rd ed., Lea and Febiger: Philadelphia, 1978.

23. Martin, A., Harbison, S. Radiation Protection, Chapman and Hall, Ltd.: London, England, 1979.
24. Moe, Lasuk, Schumacher, and Hunt. Radiation Safety Technician Training Course, Argonne National Laboratory, ANL-7291 Rev. 1, Health and Safety, May 1972, available from NTIS, USDC: Springfield, VA. 22151.
25. Morgan, K., Turner, J. Principles of Radiation Protection, Robert E. Krieger Publishing Co.: Huntington, NY., 1973.
26. Murr, G. D., Ed., Hazards in the Chemical Laboratory, 2nd ed., Chemical Society: London, 1972.
27. NIOSH/OSHA Product Guide to Chemical Hazards, DHEW (NIOSH): Sept. 1978, Publ. No. 78-210.
28. Olishifski, Julian B., NcElroy, Frank E. Fundamentals of Industrial Hygiene, National Safety Council: Chicao, IL., 1976.
29. OSHA Safety and Health Standards (29CFR1910), United States Department of Labor, OSHA, Government Printing Office: Washington, DC., (latest edition).
30. Patty, F. A. Industrial Hygiene and Toxicology: Volume II-Toxicology, Interscience Wiley: New York, 1980.
31. Proctor, N., Hughes, J. Chemical Hazards in the Workplace, Lippincott: Philadelphia, 1978.
32. Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Research Council, National Academy Press: Washington, DC., 1981.
33. Radiological Health Handbook, U.S.H.E.W., Public Health Service, F.D.A., Bureau of Radiological Health: Rockville, MD. 20852, available from U.S.G.P.O. Stock number 017-011-00043-0.
34. Safety in Academic Chemistry Laboratories. 3red ed., Committee on Chemical Safety, American Chemical Society: Washington, D.C., 1979.
35. Sax, N.I. Dangerous Properties of Industrial Materials, 5th ed., Van Nostrand-Reinhold: New York, 1979.
36. Shapiro, J. Radiation Protection, Howard University Press: Cambridge, MA., 1981.
37. Sitting, M. Hazardous and Toxic Effects of Industrial Chemicals, Noyes Data Corp.: Park Ridge, NJ., 1979.
38. Steere, N.V., Ed., CRC Handbook of Laboratory Safety, 2nd ed., CRC Press: West Palm Beach, FL., 1971.
39. TLVs: Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, TLV Airborne Contaminants Committee, American Conference of Governmental Industrial Hygienists: Cincinnat, OH., (latest edition).
40. Walters, D. C., Ed., Safe Handling of Chemical Carcinogens, Mutagens, Teratogens, and Highly Toxic Substances, Ann Arbor Science Publishers, Inc.: Ann Arbor, MI., 1980, Vol. 1.
41. Winholz, M., Ed., The Merck Index, 9th ed., Merck and Company: Rahway, NJ., 1976.
42. Zabetakis, M. G. Flammable Characteristics of Combustible Gases and Vapors, U.S. Bureau of Mines Bulletin 627, 1965.