Chemical Hygiene Plan

MURRAY STATE
UNIVERSITY

Revised 2018

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APPENDICES

MURRAY STATE UNIVERSITY
CHEMICAL HYGIENE PLAN
AWARENESS CERTIFICATION

The Occupational Safety and Health Administration (OSHA) requires that laboratory employees be made aware of the Chemical Hygiene Plan at their place of employment.

After reading the "Murray State University Chemical Hygiene Plan and Hazardous Materials Safety Manual," please complete and return a copy of this form to your supervisor or Chemical Hygiene Officer. By signing below you acknowledge that you are aware of the Chemical Hygiene Plan and the policies and procedures applicable to the OSHA standard (29 CFR 1910.1450). Your supervisor will provide additional information and training as appropriate.

Name_____Phone_____
Department_____
Job Classification_____
Course No. (if student)_____
Building_____Room_____
Supervisor, instructor, etc._____

Signature_____Date_____

Supervisors and instructors:

Please copy and distribute completed form as follows:

1. Department Chemical Hygiene Plan Training File
2. Personnel or Student File
3. Employee Copy

THE OSHA LABORATORY STANDARD

The basis for this standard (29 CFR 1910.1450) is a determination by the Occupational Safety and Health Administration (OSHA), after careful review of the complete rulemaking record, that laboratories typically differ from industrial operations in their use and handling of hazardous chemicals and that a different approach than that found in OSHA's substance specific health standards is warranted to protect workers. The final standard applies to all laboratories that use hazardous chemicals in accordance with the definitions of laboratory use and laboratory scale provided in the standard. Generally, where this standard applies it supersedes the provisions of all standards in 29 CFR, part 1910, subpart Z, except in specific instances identified by this standard. For laboratories covered by this standard, the obligation to maintain employee exposures at or below the permissible limits (PELs) specified in 29 CFR, part 1910, subpart Z is retained. However, the manner in which this obligation is achieved will be determined by each employer through the formulation and implementation of a Chemical Hygiene Plan (CHP). The CHP must include the necessary work practices, procedures, and policies to ensure that employees are protected from all potentially hazardous chemicals in use in their work area. Hazardous chemicals as defined by the final standard include not only chemicals regulated in 29 CFR part 1910, subpart Z, but also any chemical meeting the definition of hazardous chemical with respect to health hazards as defined in OSHA's Hazard Communication Standard, 29 CFR 1910.1200©.

Among other requirements, the final standard provides for employee training, medical consultation and examination (for over exposures), hazard identification, respirator use and record-keeping. To the extent possible, the standard allows a large measure of flexibility in compliance methods. (See Appendix A)

Effective Date: May 1, 1990

Compliance Date: Employers shall have completed an appropriate Chemical Hygiene Plan and commenced carrying out its provisions by January 31, 1991.

EMPLOYEES RIGHTS AND RESPONSIBILITIES

Employees have the right to be informed about the known physical and health hazards of the chemical substances in their work area and to be trained to work safely with these substances.

Employees have the right to file a complaint with OSHA if they feel they are being exposed to unsafe or unhealthful work conditions. Employees cannot be discharged, suspended, or otherwise discriminated against by their employer because of filing a complaint, or exercising their rights under the law.

Employees have the responsibility to attend training seminars on the Laboratory Safety Standard and Chemical Hygiene Plan and to stay informed about the chemicals in their work areas. They have the responsibility to use work practices and protective equipment required for safe performance of their job. Finally, they have the responsibility to inform their supervisors of conditions or work practices they believe to be a hazard to their health or to the health of others. Accidents must be reported to the supervisor.

HAZARDOUS CHEMICALS

The Laboratory Safety Standard defines a hazardous chemical as any element, chemical compound, or mixture of elements and/or compounds which is a physical or health hazard.

A chemical is a **physical hazard** if 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 material (reactive), or water 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. Included are:

- carcinogens
- irritants
- reproductive toxins
- corrosives
- sensitizers
- radioactive material
- neurotoxin (nerve)
- biohazard
- hepatotoxins (liver)
- nephrotoxins (kidney)
- agents that act on the hematopoietic system (blood)
- agents that damage the lungs, skin, eyes, mucous membranes

A chemical is considered a **carcinogen** or **potential carcinogen** if it is so identified in any of the following:

- National Toxicology Program, "Annual Report of Carcinogens" (latest edition)
- International Agency for Research on Cancer, "Monographs" (latest edition)
- OSHA, 29 CFR 1910, Subpart Z, Toxic and Hazardous Substances

A chemical is considered **hazardous** if it is listed in any of the following:

- OSHA, 29 CFR 1910, Subpart Z, Toxic and Hazardous Substances
- "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)

In most cases, the label will indicate if the chemical is hazardous. Look for key words like **caution, hazardous, toxic, dangerous, corrosive, irritant, carcinogen,** etc. Old containers of hazardous chemicals (before 1985) may not contain hazard warnings.

If you are not sure a chemical you are using is hazardous, review the s**afety data sheet (SDS)** or contact your supervisor, instructor, or the Office of Environmental Safety and Health (ESH).

SAFETY DATA SHEETS (SDSs)

A Safety Data Sheet (SDS) is a document containing chemical hazard and safe handling information and is prepared in accordance with the OSHA Hazard Communication Standard. An SDS should be obtained for each chemical used in the laboratory.

Chemical manufacturers and distributors must provide the purchasers of hazardous chemicals an appropriate SDS for each hazardous chemical/product purchased.

If an SDS was not provided with the shipment of a hazardous chemical, one should be requested from the manufacturer or distributor in a timely manner. (See the "MSU Hazard Communication Program Summary and Compliance Manual" for a sample SDS request letter).

The Office of Environmental Safety and Health (ESH), Facilities Management Building, extension 3480 is a central repository for SDSs. If you want to review an SDS, contact your supervisor, instructor, the chemical supplier, or ESH.

If your department does not have a copy of the "MSU Hazard Communication Program Summary and Compliance Manual" contact ESH at extension 3480.

CHEMICAL INVENTORIES

The OSHA Laboratory Standard does not require chemical inventories; however, the OSHA Hazard Communication Standard requires an inventory of all hazardous chemicals. An annual inventory maintained by each department or area can reduce the number of unknowns and the tendency to stockpile chemicals.

Murray State University
Chemical Hygiene Plan

The Chemical Hygiene Plan is a written plan to assist all laboratories at Murray State University using chemicals.

SCOPE AND APPLICATION

The CHP applies to all personnel at Murray State University and related facilities engaged in research activities and operations involving laboratory use of hazardous chemicals.

The CHP does not apply to:

1. Use of laboratory chemicals that do not meet the criterion of laboratory use.
2. Laboratory use of hazardous chemicals that provide no potential for employee exposure. Examples of such conditions might include:

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

Laboratory uses of chemicals not covered by the CHP are subject to the full provisions of the OSHA Hazard Communication Standard and the Murray State University Hazard Communication Program. Contact the Office of Environmental Safety and Health within the Facilities Management Department for additional information.

RESPONSIBILITY

The Murray State University Office of Environmental Safety and Health within the Facilities Management Department and the Chemical Hygiene Officer will develop the provisions of the CHP.

The overall responsibility for all University operations lies with the President and their administrative staff. The president has designated the Office of Environmental Safety and Health as the operational sub-unit for overseeing compliance with all federal, state, and local regulations relating to chemical management.

The primary responsibility of the Office of Environmental Safety and Health (ESH) is to promote safe and proper chemical management at Murray State University. Chemical management includes, but is not limited to, the procurement and the safe handling, storage, use, and disposal of chemicals. The specific duties and responsibilities of ESH shall include, but are not limited to, the following:

- Serve as consultant to administration, faculty, and staff (University Community) on matters related to chemical management.

- Be cognizant of all applicable government and University policies, procedures, guidelines, laws, and regulations related to chemical management and transmit this information in appropriate form to the University Community.

- Develop, review, and/or recommend procedures and guidelines, and to comply with applicable regulations.

- Develop, review, and recommend programs of training in chemical management for the University Community.

- Review conditions for compliance with government and/or University policies, procedures, guidelines, and regulations, and recommend appropriate corrective actions. In extreme circumstances, this may include suspension of the activity in question.

- Keep a written record of activities, actions, decisions, and recommendations of ESH.

The **Chemical Hygiene Officer** (CHO) is responsible for developing generic Standard Operating Procedures (SOPs) when laboratory work requires the use of hazardous chemicals. The CHO may assign areas of responsibility to departments, department safety and health committees, laboratory supervisors, Designated Trained Individuals (DTIs), and other individuals as necessary, to implement and carry out the provisions of the CHP.

Department Heads are responsible for implementing and maintaining the CHP in their respective work areas. For more efficient implementation of the CHP, department heads should select one of more individuals to serve as coordinators. These coordinators are referred to as **Designated Trained Individuals (DTIs).** Department safety and health committees can also assume these responsibilities.

The **Laboratory Supervisors** are responsible for chemical hygiene in the laboratories. Their responsibilities include, but are not limited to the following:

- Develop specific SOPs for each laboratory experiment requiring the use of hazardous chemicals.
- Ensure that workers know and follow the chemical hygiene rules.
- Ensure that appropriate training has been provided for specific hazards associated with the hazardous chemicals used.
- Ensure that facilities are adequate for material being used.
- Provide regular and formal chemical hygiene inspections of their facilities and equipment.
- Determine the appropriate level of protective apparel and equipment; ensure that it is available and in working order; insure that training has been provided.
- Inform all laboratory personnel of safety hazards and safety guidelines applicable to that laboratory.
- Require adherence to guidelines relating to safe usage of approved apparatus and the acquisition, storage, and disposal of hazardous materials.
- Be alert to and informed of all University, federal, state, and local regulations and policies relating to each particular laboratory operation.

- Provide instructional opportunities in techniques and safety attitudes to new laboratory personnel, as well as to more experienced lab workers.

Laboratory workers are responsible for planning and conducting each operation in accordance with University chemical hygiene procedures and for developing good personal chemical hygiene habits. The most important rule for laboratory safety is that everyone involved in the operations, from the highest administrative level to the individual worker, must be aware of his or her individual safety responsibilities. All have a basic responsibility to themselves and to their co-workers to plan and execute all laboratory operations in a manner that will not be a hazard.

Students are not covered under the provisions of the OSHA Laboratory Standard. However, students should be made aware of chemical health and safety hazards in classroom situations and should be provided with information and equipment to protect themselves from those hazards. Departments should provide student training at the beginning of each course in which hazardous chemicals are used. Specific safety instructions should be provided at the beginning of each class period.

EXPOSURE LIMITS

For laboratory uses of hazardous substances, departments must assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits (PELs) specified in 29 CFR 1910, subpart Z, or the published exposure limits, whichever is lower. If conditions create the possibility of an over exposure, contact ESH for technical assistance and evaluation to determine if monitoring is necessary. Monitoring will be done in accordance with ACGIH approved analytical methods.

EMPLOYEE INFORMATION AND TRAINING

Departments must provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area. Training may take the form of individual instruction, group seminars, audiovisual presentations, handout material, or any combination of the above. However, the training must include the specific hazards associated with the chemicals in the work area when generic training is insufficient (e.g., extremely toxic materials, carcinogens, reproductive hazards) to address specific hazards. A variety of training aids are available from ESH.

Such information must be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignment involving new exposure situations. Employees should receive periodic refresher information and training.

Note: Although the length of training is not specified in the OSHA regulations, effective information and training generally will take at least 2 hours for most laboratory scale operations. The frequency of periodic refresher information and training will vary with the hazard; however, the length of time between training sessions should not exceed two years.

Information. Information provided by departments to employees must include:

1. The contents of the OSHA standard 29 CFR 1910.1450 and its appendices which shall be available to employees (See Appendix A);
2. The location and availability of the Murray State University Chemical Hygiene Plan in each department (also available from ESH);
3. The permissible exposure limits for OSHA regulated substances or published exposure limits for other hazardous chemicals where there is no applicable OSHA standard (available from ESH);
4. Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory (available on container labels and safety data sheets);
5. The location and availability of known reference material on the hazards, safe handling, storage, and disposal of hazardous chemicals found in the laboratory (see other applicable sections of this document) including, but not limited to, safety data sheets received from the supplier.

Training. Training provided by departments to employees must include:

1. Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the University, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
2. The physical and health hazards of chemicals in the work area;
3. The measures employees can take to protect themselves from these hazards, including specific procedures the University or department has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used;
4. The applicable details and where they are located in the Murray State University Chemical Hygiene Plan.

Documentation. Training required by the CHP should be documented using the tear-out form at the beginning of this booklet. Copies of the form must be kept in each work area or department. Student training should be documented in the same fashion and maintained in the area of department.

MEDICAL CONSULTATIONS AND EXAMINATIONS

Medical consultations and examinations are to be performed whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory; where exposure monitoring reveals an exposure level routinely above the action level, or the PEL for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements; and whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure.

All medical consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place. The examination cost will be the responsibility of the employees department, university health plan, or workmen's compensation.

HAZARD IDENTIFICATION

With respect to labels and safety data sheets:

1. Departments must ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
2. Departments must ensure that laboratory containers of chemicals are labeled where required. Laboratory containers, including bottles, flasks, sample vials, etc., must be marked, labeled, or coded in all cases. This will aid in preventing any confusion concerning chemical identification. The label should be dated and should identify the owner of the material.
3. Departments must maintain any safety data sheets that are received with incoming shipments of hazardous chemicals and ensure that they are readily accessible to laboratory employees.

NOTE: ESH has an extensive inventory of safety data sheets on file. SDSs are also available from the supplier. SDSs for chemicals in use should be maintained in the laboratory.

CHEMICALS DEVELOPED IN THE LABORATORY

The following requirements apply to chemical substances developed in the laboratory:

1. If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the principal investigator must determine if it is a hazardous chemical e.g., by literature search). If the chemical is determined to be hazardous, the principal investigator must provide appropriate training to protect employees.

2. If the chemical produced is a by-product whose composition is not known, the principal investigator must assume that the substance is hazardous and must comply with the requirements of the CHP.

3. If the chemical substance is produced for another user outside of the laboratory, the principal investigator must comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements of the safety data sheets and labeling. This requirement applies to production laboratories, not research or teaching laboratories.

NOTE: Item 1 does not require the principal investigator to conduct toxicological testing. However, if the safety data sheet or hazard information is available for the chemical, the information must be made available to employees.

USE OF RESPIRATORS

Where the use of respirators is necessary to maintain exposure below permissible exposure limits or the published exposure limits, the department must provide, at no cost to the employee, the proper respiratory protective equipment, training, and physicals. Respirators must be selected and used in accordance with the requirements of the Murray State University Respiratory Protection Program (contact ESH for additional information).

STANDARD OPERATING PROCEDURES

The Chemical Hygiene Officer will develop generic standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals. Departments, department safety and health committees, and laboratory supervisors will develop written standard operating procedures for work area specific operations. Standard operating procedures must be provided to affected employees.

For work involving extremely toxic chemicals, select carcinogens, and reproductive toxins, standard operating procedures must include the following provisions where appropriate:

1. Establishment of a designated area;
2. Use of containment devices such as fume hoods or glove boxes;
3. Procedure for safe removal of contaminated waste; and
4. Decontamination procedures.

CONTROL MEASURES

Whenever employee exposures exceed the action level (or in the absence of an action level, the permissible exposure limit or the published exposure limit), the department must implement control measures to reduce the employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices. Exposures to extremely toxic materials, select carcinogens, and reproductive toxins must be maintained as low as reasonably achievable.

PROTECTIVE EQUIPMENT

Users of hazardous chemicals must ensure fume hoods and other protective equipment are adjusted and functioning properly prior to initiating an activity requiring their use.

Department heads will ensure fume hood performance is evaluated annually and repairs made when necessary.

SPECIAL HAZARDS

ESH and the Chemical Hygiene Officer will develop circumstances under which a particular laboratory operation, procedure or activity will require approval before implementation.

NOTE: OSHA requires each employer to identify those activities which the employer believes to be of a sufficiently hazardous nature to warrant prior "employer approval" before implementation. The Chemical Hygiene Officer intends to identify activities that involve extremely toxic chemicals, select carcinogens and reproductive hazards, and those activities with a high potential for personal injury and property damage. Departments will also need to identify existing activities subject to the requirements of

this section. Except for the most hazardous activities, "employer approval" will occur at the local level (e.g., Department Safety and Health Committee). The Chemical Hygiene Officer is available for assistance.

AVAILABILITY

The Chemical Hygiene Plan must be readily available to employees and employee representatives.
NOTE: Additional copies of this document are available from ESH.

HAZARDOUS MATERIALS SAFETY MANUAL

SAFE HANDLING OF CHEMICALS

Know the physical health hazards associated with the chemical(s) you are using. Consider the physical state (gas, liquid, or solid) of the material(s). Consider the process in which you are using the chemical(s), the facilities you have for storage if the materials, and the facilities and equipment you may need to handle an emergency. Know the procedures necessary for safe disposal of the chemical.

Questions you should consider:

1. Is the material flammable, explosive, corrosive, or reactive?
2. Is the material toxic, and if so, how can I be exposed to the material (inhalation, skin or eye contact, accidental ingestion, accidental puncture)?
3. What kind of ventilation do I need to protect myself? What kind of personal protective equipment (i.e. gloves, respirators, goggles) do I need to protect myself?
4. Will the process generate other toxic compounds, or could it result in a fire, explosion, etc.?
5. Are my storage facilities appropriate for the type of materials I will be using? Can I properly segregate incompatible materials?
6. What possible accidents can occur and what steps can I take to minimize the likelihood and impact of an accident?
7. What are the proper procedures for disposal of the chemicals?

Once you evaluate the potential hazards associated with the chemical(s) and the process, you can design your process and work procedures to minimize or eliminate the hazards.

The following sections provide work procedures and engineering controls that can be used to minimize or eliminate hazards in the laboratory. If you have any questions about any information in these sections, please contact ESH at 809-3480.

GENERAL SAFETY GUIDELINES

Know the hazards associated with the materials you are using. Carefully read the label before using a chemical. Review the Safety data sheet (SDS) for any special handling information. In some cases it may be necessary to do additional research. Contact ESH (3480) for assistance with the evaluation of hazards associated with a specific material.

Be prepared for hazardous material emergencies and know what action to take in the event of an emergency. Assure necessary supplies and equipment are available for handling small spills of hazardous materials.

Know the location of safety equipment: emergency shower, eyewash, fire extinguisher, fire alarm pull station.

Do not work alone in the laboratory if you are working with hazardous materials.

Purchase the minimum amount of hazardous materials necessary to accomplish your work and dispense only the minimum amount necessary for immediate use.

Use hazardous chemicals only as directed and for their intended purpose.

Never smell or taste a hazardous chemical.

Vent apparatus that may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices.

Inspect gloves and test fume hoods and glove boxes before use.

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

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

Assure ventilation is adequate for the materials used. Refer to the SDS for information on ventilation requirements or contact ESH. See the "Engineering Controls" section of this booklet.

Avoid direct contact with any chemical. Keep chemicals off hands, face and clothing, including shoes.

Avoid practical jokes or other behavior that might confuse, startle or distract another worker.

Confine long hair and loose clothing. Wear closed-toe shoes at all times in the laboratory. Do not wear sandals or perforated shoes.

Keep the work area clean and uncluttered with chemicals and equipment. Clean up the work area on completion of an operation or at the end of each work day.

Use required personal protective equipment. See "Personal Protective Equipment" section of this booklet. Remove laboratory coats immediately on significant contamination.

Label all secondary containers with appropriate hazard information. Assure labels on primary and secondary containers do not become damaged. Replace them when necessary.

Use good hygiene. Keep your hands and face clean. Wash thoroughly with soap and water after handling any chemical.

Smoking, drinking, eating, and the application of cosmetics is forbidden in areas where hazardous chemicals are in use.

Never use mouth suction to fill a pipet. Use a pipet bulb or other pipet filling device.

Electrically ground and bond containers using approved methods before transferring or dispensing a flammable liquid from a large container.

Promptly clean up spills, using appropriate protective apparel, equipment and procedures. See the "Emergency Response" section of this booklet.

Assure adequate storage facilities and containers are provided for hazardous materials. See the "Chemical Storage" section of this booklet.

For unattended operations, leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of a utility service failure (e.g., loss of cooling water). Plans to conduct unattended operations should be reviewed with the laboratory supervisor or Chemical Hygiene Officer.

For specific information regarding chemical handling contact your laboratory supervisor, Chemical Hygiene Officer, or ESH.

ENGINEERING CONTROLS

Exposure to hazardous materials should be controlled to the greatest extent feasible by use of engineering controls. For assistance in determining engineering controls necessary for your work situation, contact ESH. Engineering controls to reduce or eliminate exposures to hazardous chemicals include:

- Substitution of less hazardous equipment, chemical or process (e.g., plastic for glass bottles)
- Isolation of the operator or the process (e.g., use of barriers when handling explosive material, or completely enclosing process in glove box or other enclosure)
- Local and general exhaust ventilation (e.g., use of fume hoods)

Ventilation Controls. To determine ventilation requirements, check the SDS. Expressions on the SDS such as those listed below indicate a need for ventilation:

- Use with adequate ventilation
- Use in fume hood ventilation
- Avoid vapor inhalation
- Provide local exhaust

Ventilation recommendations must be adapted to the work-site and the specific process. For assistance in determining specific ventilation requirements for your work situation, contact ESH.

Proper Use of Ventilation Systems. As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a PEL or TLV of less than 50 ppm.

Once a ventilation system is installed in a work area, it must be used properly to be effective. The objective of a local exhaust ventilation system is to draw hazardous materials in the air away from the breathing zone of the employee.

The system must be checked prior to each use to assure it is operating. If the system is not working, it should be posted "out of order" and the Chemical Hygiene Officer should be contacted. Never do work with hazardous materials if the required ventilation system is not working.

Ventilation systems must be properly configured. Be sure you know how to properly use the system in your area for the work you are doing. For use of laboratory fume hoods, the following guidelines should be followed:

1. Fume hoods should be marked to indicate proper sash position for optimum hood performance. The hood sash should be set at this point for procedures that could generate toxic aerosols, gases or vapors. If it is not possible to do work with the sash height set at the point marked, or if there is no marking on the hood, contact ESH. In general, the sash height should be set at a level where the operator is shielded to some degree from any explosions or violent reactions which could occur and where optimum airflow dynamics are achieved. Fume hoods should not be used with the sash fully open.

2. Fume hoods should be equipped with a manometer or magnehelic gauge to indicate adequacy of flow. Learn how to read and interpret this gauge, and check it daily. If the gauge indicates a reduced flow in the hood, post the hood "out of order" sign and contact the Chemical Hygiene Officer and notify Facilities Management at 4291 for repairs.

3. Only apparatus and chemicals essential to the specific procedure or process should be placed in the hood. Extraneous materials from previous experiments or procedures should be removed and stored in a safe location outside the hood. Hoods used for experimental work should not be used for chemical or material storage. Hoods used for chemical storage should be dedicated to chemical storage. No experimental work should be conducted in these hoods.

If there are any questions concerning the adequacy of a fume hood or the procedures for safe use of a fume hood, contact ESH.

PERSONAL PROTECTIVE EQUIPMENT

General Considerations. Personal protective devices may be needed to supplement available engineering controls, but are never used as a substitute for engineering controls except as a temporary measure while such controls are being instituted or for short-term jobs where the implementation of engineering controls is not feasible.

The SDS will provide some information on the personal protective equipment recommended for use with the chemical. The SDS addresses "worst case" conditions; therefore, all the equipment described may not be necessary for a specific job. In addition, the SDS may not provide sufficient information concerning a specific respirator or type of glove appropriate for the chemical.

Your lab supervisor or Chemical Hygiene Officer will determine which personal protective devices are required for each task; however, use common sense – there is no harm in being over protected. Failure to use required personal protective equipment could result in personal injury and disciplinary action.

Departments must provide required personal protective equipment to employees.

Protection Against Inhalation Hazards. When ventilation is not adequate to provide protection against an inhalation hazard, respiratory protective equipment may be necessary. There is a variety of respiratory protective equipment available for use, but no one device will provide protection against all possible hazards. Respirator selection is based on the chemical and process hazard, and the protection factors required.

Types of respiratory protective equipment include:

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

Respirators are not to be used except in conjunction with a comprehensive respiratory protection program. Such a program includes a review of the process to assure the proper equipment is selected for the job; training of all respiratory protective equipment users concerning the methods for proper use and care of such equipment; fit-testing for respirator users; and medical surveillance of respirator users.

If your work requires the use of a respirator or you suspect your work requires the use of a respirator, you should contact your supervisor. He/she will contact ESH for an evaluation of the exposure and schedule fit-testing and training.

Do not use respiratory protective equipment until you have received proper training. If you are currently using a respirator and you have not received training in its use and care, contact ESH immediately.

In some cases, respiratory protective equipment may be kept on hand for an emergency. In this situation, all potential users must receive training in its use. In addition, the equipment must be inspected on a monthly basis and this inspection must be documented. If you have respiratory protective equipment on-hand for use in an emergency and you have not received training in its use and care, contact ESH.

For more information on the Murray State University Respiratory Protection Program, contact ESH at 3480.

Protection of Skin and Body. Skin and body protection involves the use of protective clothing to protect various parts of the body.

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

- Safety glasses with side shields for dust and flying objects
- Splash-proof goggles for chemical splashes, sprays and mist
- Full-face and neck shields for head and neck protection from various hazards (must be used with safety glasses/goggles)

Splash proof goggles provide superior protection against dust, flying objects, and splash, spray and mist hazards. They should be the first choice for primary eye protection.

Cover all unprotected skin surfaces. Do not wear open-toe shoes, sandals, shorts, etc., in a chemical laboratory.

Even when there is minimal danger of skin contact with a hazardous substance, lab coats, coveralls, aprons, or protective suits should be utilized. General categories of contaminants include:

- Dirt and grease
- Toxic dust (asbestos)
- Lab chemicals
- Bacterial agents
- Radioactive materials

For heavily contaminated work, special attention must be given to sealing all openings in the clothing. Duct tape can be utilized for this purpose. Caps should be worn to protect hair from contamination.

Exposure to strong acids, organic chemicals, strong oxidizing agents, carcinogens, and mutagens require the use of protective equipment that prevents skin contamination. Impervious protective equipment must be utilized. Examples include:

- Rubber gloves
- Rubberized suits
- Rubber boots

- Special Protective Equipment

Protective garments are not equally effective for every hazardous chemical. Some chemicals will "break through" the garment in a very short time; therefore, garment selection is based on the specific chemical utilized. General selection criteria is provided in Table 1 at the end of Part II. Determine what chemicals are to be used, then refer to the table or contact your supervisor, instructor, or ESH for specific clothing recommended.

ADMINISTRATIVE CONTROLS

Administrative controls are procedural measures that can be taken to reduce or eliminate hazards associated with the use of hazardous materials. Administrative controls include the following:

- Careful planning of experiments and procedures with safety in mind.
- Planning includes the development of written work procedures for safe performance of the work.
- Restricting access to areas in which hazardous materials are used.
- Using signs or placards to identify hazardous areas (designated areas).
- Use of labels on hazardous materials.
- Substitution of less toxic materials for toxic materials.
- Good housekeeping
- Good hygiene (e.g. washing hands and other areas of possible chemical contact).
- Prohibiting eating, drinking, and smoking in areas of chemical use, and providing break areas for this purpose.
- No mouth pipetting.
- Assuring employees are provided adequate training for safe work with hazardous materials.
- Scheduling so that employees are not alone when working with hazardous materials.

Restricted access and designated areas. Facilities placarded with the following warning signs are restricted access, designated areas:

- **CAUTION-REPRODUCTIVE HAZARD**
- **CAUTION-BIOHAZARD**
- **CANCER-HAZARD**
- **CAUTION-RADIOACTIVE HAZARD**
- **CAUTION-RADIATION AREA**
- **CAUTION-X-RAY**
- **CAUTION-LASER**

A list with names and phone numbers of responsible personnel should be posted on the door(s) to any restricted access, designated areas.

Students, faculty, staff and administrators should not enter a restricted area, except when accompanied by an authorized user of the facility.

Custodians are permitted to enter restricted areas to perform routine tasks; however, custodians should not touch labeled waste containers, other research equipment or materials.

Other support personnel, such as Public Safety, ESH, plumbers, electricians, etc. are permitted to enter restricted areas provided the work to be performed does not disturb the experiment, or materials. Examples include:

- Fume hoods/Sinks
- Chemical or materials on lab benches
- Biological safety cabinets
- Placarded equipment

Support personnel should contact an authorized user of the facility or ESH before performing work which may involve any of the above items.

Immediately notify Public Safety or ESH of any emergency or unusual conditions such as:

- Chemical spills
- Injury
- Chemical container leaks
- Biological contamination
- Fires

For additional information concerning restricted access, designated areas, contact your supervisor, instructor, or ESH.

CHEMICAL STORAGE

Carefully read the label before storing a hazardous chemical. The SDS will provide any special storage information and incompatibilities.

Assure all containers are in good condition and properly labeled.

Do not store unsegregated chemicals in alphabetical order.

Do not store incompatible chemicals in close proximity to each other.

Separate hazardous chemicals in storage as follows:

- Flammable/combustible liquids
- Flammable solids
- Mineral acids
- Organic acids
- Caustics
- Perchloric acid
- Water reactive
- Air reactive
- Heat reactive (require refrigeration)
- Unstable (shock-sensitive, explosive)
- Others
- Gases: Toxic
  Flammable
  Oxidizers and inert

Once separated into hazard classes, chemicals may be stored alphabetically.

Determine what equipment and space is needed for safe storage of chemicals.
Use approved storage cabinets, containers and safety cans for flammable liquids.

Refrigerators and freezers used for the storage of flammable or combustible liquids must have no internal sources of ignition (explosion-proof).

Do not store chemicals on refrigerator door shelves. Containers could fall when the door is opened or closed.

Flammable liquids stored in glass containers shall not exceed 1 quart. Exception: For conditions where chemical purity must be protected, flammable liquids stored in glass containers shall not exceed 1 gallon.

Use corrosion resistant cabinets for storage of corrosives.

Use spill trays under containers of strong reagents.

Dispose of expired chemicals promptly. See "Waste Disposal" section of this manual.

Recycle excess chemicals no longer being used in your area.

Contact ESH for recycling information.

Do not store liquids above eye level.

Avoid floor chemical storage.

Provide anti-roll lips on shelves.

Don't store chemicals on top of shelving units.

Avoid use of adjustable supports with clips.

Store severe poisons in a dedicated cabinet.

For more information on chemical storage, contact your supervisor, instructor, or ESH.

Suggested chemical storage patterns.

For laboratories that have moderate to large numbers of diverse chemicals and hazard classes one may use the suggested storage pattern outlined in the 1984 U.S. Consumer Product Safety Commission's publication entitled "School Science Laboratories- A Guide to Some Hazardous Substances," a combination of the J.T. Baker and Flinn Scientific storage room. Be careful to check each chemical stored in an area for compatibility. Don't assume anything when it comes to correct chemical storage.

J.T. Baker's SAF-T-DATA Label

Red	Flammability hazard: store in a flammable chemical storage area.
Red Stripe	Flammability hazard: do not store in same area as other flammable substances.
Yellow	Reactivity hazard: store separately from other chemicals.
Yellow Stripe	Reactivity hazard: do not store with other yellow coded chemicals, store separately.
White	Contact hazard: store separately in a corrosion proof location.
White Stripe	Contact hazard: not compatible with chemicals in solid white category.

Blue Health hazard: Store in a secure poison area.

Orange Not suitably characterized by any of the foregoing categories.

Once separated into color codes, chemicals should be further sorted into organic and inorganic classes. This should arrange then into compatible families.

Compatible Families

Inorganic:

1. metals, hydrides
2. halides, sulfates, sulfites, thiosulfates, phosphates, halogens
3. Amides, nitrates**(except ammonium nitrate), nitrites**, azides**, nitric acid
4. hydroxides, oxides, silicates, carbonates, carbon
5. sulfides, selenides, phosphides, carbides, nitrides
6. chlorates, perchlorates**, perchloric acid**, hypochlorites, peroxides**, hydrogen peroxide
7. arsenates, cyanides, cyanates
8. borates, chromates, manganates, permanganates
9. acids (except nitric)
10. sulfur, phosphorous, arsenic, phosphorous pentoxide**

Organic:

1. acids, anhydrides, peracids
2. alcohols, glycols, amines, amides, imines, imides
3. hydrocarbons, esters, aldehydes
4. ethers**, ketones, ketenes, halogenated hydrocarbons, ethylene oxide
5. epoxy compounds, isocyanates
6. peroxides, hydroperoxides, azides**
7. sulfides, polysulfoxides, nitriles
8. phenols, cresols

**These chemicals deserve special attention due to their potential instability.

The color scheme used in Fisher's ChemAlert chemical labeling system is slightly different from Bakers.

Fisher's ChemAlert Label

- Red – Flammable
- Blue – Health
- Yellow – Reactivity
- White – Corrosive
- Gray – General Chemical Storage

- "Stop" – Exception—reagent incompatible with other reagents of same color bar. Store separately.

Pictograms

	**Exploding bomb** (for explosion or reactivity hazards)		**Flame** (for fire hazards)		**Flame over circle** (for oxidizing hazards)
	**Gas cylinder** (for gases under pressure)		**Corrosion** (for corrosive damage to metals, as well as skin, eyes)		**Skull and Crossbones** (can cause death or toxicity with short exposure to small amounts)
	**Health hazard** (may cause or suspected of causing serious health effects)		**Exclamation mark** (may cause less serious health effects or damage the ozone layer*)		**Environment*** (may cause damage to the aquatic environment)

Some chemical suppliers use "pictograms" on labels to depict hazard classes rather than color coding. Be careful to match pictograms with color codes. For chemicals that lack hazard class information on the label, use the suppliers catalog, SDS, or manufacturer to determine appropriate classification.

CONTAMINATED CLOTHING AND PROTECTIVE EQUIPMENT

When splash or spill of hazardous chemicals on clothing or protective equipment occurs, the clothing/equipment should be removed and placed in a closed container which prevents dispersion of the hazardous chemical. The clothing/equipment should be disposed of, cleaned, or laundered as appropriate. Employees should not take contaminated clothing/equipment home for cleaning or laundering. Employees who clean or launder contaminated clothing or equipment must be informed of the potentially harmful effects of exposure to the chemical contaminant.

WASTE DISPOSAL

Hazardous chemical disposal must be conducted in accordance with procedures established by ESH. Contact ESH at 3480 for specific information on disposal procedures.

Unless approved by ESH, disposal of chemicals via the sanitary sewer system is not permitted. Disposal of radioactive material and infectious waste requires special procedures. Contact ESH before proceeding.

SPECIAL PRECAUTIONS FOR HAZARDOUS CHEMICALS

The Laboratory Standard defines a hazardous chemical as any element, chemical compound, or mixture of elements and/or compounds that are a physical hazard or a health hazard. The standard also requires the employer to develop circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer before implementation. The Chemical Hygiene Officer (CHO) is the University's designee for defining and approving such operations, procedures or activities. Prior to initiating a project, determine if the approval of the Chemical Hygiene Officer is required. A list of affected activities is available from the CHO.

The special precautions contained in this section are in addition to those detailed under "General Safety Guidelines."

PHYSICAL HAZARDS

"Physical hazard" refers to a chemical for which there is evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water reactive. Materials that present a physical hazard can be safely used if the specific hazard(s) are understood, and measures are taken to address the hazards. If appropriate precautions are not taken, a fire, an explosion, unwanted corrosion, personal injury, or property damage could occur.

Certain 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. See Appendix B for a table of incompatible chemicals.

PROCEDURES FOR SAFE HANDLING OF FLAMMABLES AND COMBUSTIBLES

Flammable/combustible materials can generate sufficient vapor to cause a fire in the presence of an ignition source. They are categorized based on flash point-the minimum concentrations to allow the substance to ignite.

Flammable – Materials that can generate sufficient vapors to ignite at temperatures below 100ºF.

Combustible – Materials that can generate sufficient vapors to ignite at temperatures at or above 100ºF and below 200ºF.

The vapors of these materials are invisible. The rate of vapor generation depends upon the liquid's vapor pressure, which increases with temperature. The degree of fire hazard depends upon the ability of vapors to mix with air to form combustible or explosive mixtures and the ease of ignition of these mixtures. Flammables are more hazardous because they are more volatile than

combustibles. Safe handling procedures are based upon controlling one or more of the elements necessary to initiate a fire: fuel, ignition source, and oxygen. In addition, combustible materials react with oxidizers which can result in a fire.

Precautions

1. Eliminate ignition sources such as open flames, smoking materials, hot surfaces, sparks from welding or cutting, operation of electrical equipment, and static electricity. Post conspicuous "No Smoking" signs in areas where flammable materials are used or stored.

2. Minimize the quantity of flammables/combustibles kept in work area.

3. Store in approved flammable liquid containers (safety cans) and storage cabinets or in a special storage room designed for that purpose. Store away from oxidizers.

4. Flammable liquids stored in glass containers shall not exceed one quart unless chemical purity must be protected. In that case one gallon is permissible.

5. Refrigerators and freezers used for storage of flammable or combustible liquids must have no internal sources of ignition (explosion-proof).

6. Assure proper bonding and grounding when transferring or dispensing flammable liquids from a large container or drum. Assure bonding and grounding is checked periodically.

7. Assure appropriate sprinkler and or fire extinguishers are in the area.

Procedures for safe storage of flammable/combustible liquids.

The following is a summary of storage requirements for ignitable liquids taken from OSHA 1910.106 and NFPA 30, 49, and 704.

Storage limitations of liquids are based on the following classifications:

Term	Class	Flash Point	Boiling Point	NFPA Rating
Flammable	IA	<73ºF	<100ºF	4
Flammable	IB	<73ºF	= or> 100ºF	3
Flammable	IC	73ºF	-<100ºF	3
Combustible	II	100ºF	-<140ºF	2
Combustible	IIIA	140ºF	-<200ºF	2
Combustible	IIIB	200ºF & above		1

The following storage requirements apply to most university, academic and research areas. For guidelines pertaining to flammable storage vaults, warehouses and industrial operations, contact ESH.

Whenever possible all flammable liquids should be placed in storage cabinets.

1. Maximum storage in a fire area (room with approved walls and doors) **outside** of approved storage cabinets:

    - 10 gallons of Class I and II liquids combined or 25 gallons of Class I and II liquids in safety cans.

    - 60 gallons of Class IIIA liquids.

2. Maximum storage **inside** storage cabinet. No more than three flammable storage cabinets may be located in a single fire area:

    - 120 gallons of Class I, II, and IIIA liquids of which not more than 60 gallons may be of Class I and II liquids.

3. Class I liquids may not be stored in basement areas.

PROCEDURES FOR HANDLING CORROSIVES

A corrosive chemical is one that causes visible destruction or irreversible alterations of living tissue by chemical action at the site of contact. They can be in solid, liquid, or gaseous form and act on the body tissues by direct contact, inhalation or ingestion. Corrosive materials can react with the skin causing burns similar to thermal burns, and/or can react with metal causing deterioration of the metal surfaces. Corrosives can be categorized as strong acid, strong base, dehydrating agent, oxidizing agent or water-reactive. Corrosive liquids are responsible for most corrosive-based injuries. Corrosive gases are the most serious because they can be readily absorbed into the body by dissolution with skin moisture and by inhalation.

Precautions

1. Eye protection and rubber gloves should always be worn when handling corrosive materials. Face-shield, rubber apron, and rubber boots may also be appropriate, depending upon work performed (check safety data sheet for personal protective equipment requirements).

2. Persons who wear contact lenses in laboratories should also wear goggles or a face shield.

3. An eyewash and safety shower must be readily accessible to areas where corrosives are used and stored as specified in OSHA 1910.151(c). In the event of skin or eye contact with corrosives, immediately flush the area of contact with cool water for 15 minutes. Remove all affected clothing. Get medical help immediately.

4. **Always add acid to water.** Dehydrating agents such as sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide should be mixed with water by adding the agent to water to avoid violent reaction and splattering.

5. Strong oxidizing agents such as chromic and perchloric acids should be stored and used in glass or other inert containers (preferably unbreakable); corks and rubber stoppers should not be used.

Procedures for safe storage of corrosives.

1. Containers and equipment used for storage should be corrosion resistant.

2. Acids and bases should be stored separately from each other. Organic acids should be stored with flammable materials, separate from oxidizers including oxidizing acids.

PROCEDURES FOR HANDLING PEROXIDIZABLES

Peroxidizables are materials which react with oxygen to form peroxides which can explode with impact, heat, or friction such as removing a lid. Since these chemicals may be packed in an air atmosphere, peroxides can form even though the container has not been opened. Peroxide-forming compounds can be divided into three hazard categories. Storage times are based on time after opening container.

1. Compounds forming peroxides that can spontaneously decompose during storage. **Maximum storage time 3 months.**
   Examples include:
   * Divinyl acetylene
   * Isopropyl ether
   * Potassium metal
   * Sodium amide
   * Vinylidene chloride

2. Compounds forming peroxides that require the addition of a certain amount of energy (distillation shock) to explosively decompose. **Maximum storage time 12 months.**
   Examples include:
   * Acetal
   * Cyclohexene
   * Decahydonaphthalene
   * Diethylene glycol
   * Diacetylene
   * Dicyclopentadiene
   * 1,2-dimethoxyethane
   * Ethyl ether
   * Ethylene glycol dimethyl ether
   * Methyl acetylene
   * Methyl cyclopentane
   * Diethylene glycol
   * Tetrahydrofuran
   * Methyl isobutylketone
   * Tetrahydronaphthalene
   * Vinyl ethers

3. Compounds that have the potential to form peroxide polymers, a highly dangerous form of peroxide which precipitate from solution easily and are extremely heat and shock-sensitive. **Maximum storage time 12 months.**
Examples include:

* Acrylic acid
* Butadiene
* Chlorotrifluoroethylene
* Stryene
* Vinyl acetate
* Vinyl pyridine
* Acrylonitrile
* Chloroprene
* Methyl methacrylate
* Tetrafluoroethylene
* Vinyl chloride

Precautions

1. Date all peroxidizables upon receipt and opening. Unless an inhibitor has been added by the manufacturer, materials should be disposed of properly after the time limits listed above.

2. Do not open any container which has obvious crystals formation around lid.

3. Other precautions are similar to those used for flammables.

4. Hazards of peroxide formation can be minimized by adding oxidation inhibiting compounds, e.g., alcohol in ethyl ether. Peroxides can be tested by adding a few crystals of tetra-n-hexylammonium iodide (CAS #2138-24-1) to 0.5 –1 ml solvent, shake, place in boiling water for one minute, then cool in ice water. If solvent does not turn yellow, peroxide concentration is less than 10^{-6} molar; a yellow color indicates the presence of peroxides. To remove peroxides, add a few solid lumps (not powder) of calcium hydride to solvent. Any calcium compounds that may form are insoluble in organic solvents. Peroxides may also be tested for with EM Quant Test Strips – 10011 Peroxide Test (EM Science distributed by VWR Scientific).

PROCEDURES FOR HANDLING REACTIVE CHEMICALS

The category "Reactive" is a term given to a chemical class that displays a broad range of reactions. This category includes explosives, oxidizers, reducers, water sensitive, acid sensitive, air sensitive, and unstable chemicals. These substances are capable of producing toxic gases, explosive mixtures, being explosive, reacting with water violently or they may contain cyanide or sulfide. Reactive chemicals exhibit moderate to extremely rapid reaction rates and include materials capable of rapid release of energy by themselves (self-reaction or polymerization), and/or rates of reaction that may be increased by heat, pressure or by contact with incompatible substances.

Reactives may be broadly classified into two groups: those that may explode and those that do not. Reactivity of individual chemicals in specific chemical classes (e.g. alkali metals) varies considerably. This rate of activity may also vary as a result of aging or contamination. Reactives may be further subdivided and placed into eight classes based upon their chemical behavior.

Class I

Chemicals normally unstable that readily undergo violent change without detonating.

Properties

1. **Pyrophoric**—materials which ignite spontaneously upon contact with air. Often the flame is invisible.
   Examples include:
   * metal alkyls
   * silicone tetrachloride
   * silane
   * white and yellow phosphorus
   * finely divided metal powders such as magnesium, aluminum, and zinc

2. **Polymerizable**—spontaneous polymerization in contact with air.
   Examples include:
   * divinyl benzene

3. **Oxidizer—**materials which react with other substances by giving off electrons and undergoing reduction. Oxidizers react violently with organic materials or strong reducing agents. This reaction may result in fire or explosion. The intensity of the reaction depends on the oxidizing-reducing potential of the material involved. Oxidation reactions are the most frequent cause of chemical accidents.
   Examples include:
   * perchloric acid
   * fuming nitric acid
   * chromic acid

Precautions

1. Pyrophoric—prevent contact with air or water; use and store in inert environments.

2. Polymerizable—keep cool and avoid contact with water.

3. Oxidizer—know the reactivity of materials involved in experiment or process.

4. Do not keep excessive amounts of material in the vicinity of process.

5. Store properly, away from organic materials, flammable materials and reducers.

6. If the reaction can be violent or explosive, use shields or other methods for isolating the materials or process.

7. Use the minimum amount necessary for procedure.

Class II

Chemicals that react violently with water.

Properties

Causes large evolution of heat in contact with water, decomposes in moist air and violently decomposes
with liquid water.
Examples include:

* sulfuric acid
* oleum
* phosphorous pentoxide
* phosphorous halides
* glyoxal
* chlorosulfonic acid
* phosphorous trioxide
* acetyl halides
* titanium tetrachloride

Precautions

1. Handle materials like corrosives. Use protective acid resistant rubber or plastic clothing with gloves and face shield.

2. Keep away from moisture.

3. Handle materials in fume hood since fuming in moist air can result in exposure to corrosive and/or toxic toxic gases.

Class III

Chemicals that form potentially explosive mixtures with water.

Properties

Chemicals decompose violently in water with evolution of heat and flammable gases which may ignite if exposed to an ignition source. Evolution of heat with water may be sufficient to cause auto-ignition and/or explosion.
Examples include:

* alkali metals such as lithium, sodium, and potassium
* acid anhydrides
* acid chlorides

Precautions

1. Provide ventilation to disperse flammable gases.

2. Use of water as a fire extinguisher may aggravate fire, use dry sand to smother materials.

3. Avoid contact with and handle away from water sources.

Class IV

Chemicals that when mixed with water generate toxic gases, vapors or fumes in quantity sufficient to present a danger to human health or the environment.

Properties

Reacts rapidly with water with the production of gases or vapors which are acutely toxic to human health. Examples include:

* alkaline metal phosphides
* aluminum phosphide toluene diisocyanate
* phosphorous halides

Precautions

1. Provide adequate ventilation when handling.

2. Keep containers sealed when not in use.

3. Do not handle near water.

4. Store away from water sources.

Class V

Cyanide or sulfide bearing chemicals.

Properties

Acid sensitive cyanides and sulfides that produce extremely toxic hydrogen cyanide or hydrogen sulfide gases on contact with acids or materials which form acids in the presence of moisture or liquid water.
Examples include:

* metal cyanide salts
* metal sulfide salts
* mercaptans
* organic cyanide compounds
* organic sulfides

Precautions

1. Do not store in cabinets with acids and oxidizers.

2. Isolate from other reactive chemicals.

3. Protect sulfide salts from moisture.

4. Provide adequate ventilation due to severe inhalation hazard of hydrogen cyanide and hydrogen sulfide gases, and acute toxic effects from skin contact with hydrogen cyanide.

Class VI

Chemicals capable of detonating or exploding if subjected to a strong initiating source or if heated under confinement.

Properties

Detonation or explosion can occur if heated above ambient temperature or if exposed to an initiating source such as shock, spark or flame, or a catalyst which accelerates decomposition.
Examples include:

* lead amide
* thallous nitride
* brominated organic compounds
* ammonium picrate
* metal periodates
* isoamyl nitrite
* perchlorates
* sodium amide
* metal azides
* benzene diazonium salts
* ammonium tetrachromate
* organic perchlorates
* ammonium nitrate

Precautions

1. Protect containers from physical damage, heat and incompatible chemicals.

2. Chemicals in this class exhibit a wide range of other properties, i.e., flammability, acid sensitivity, water sensitivity, or light sensitivity. Know the properties of the materials being worked with.

3. Check SDS for information on incompatibilities when storing.

Class VII

Chemicals readily capable of detonation, explosive decomposition, or reaction at standard temperature and pressure.

Properties

Chemicals capable of detonation or explosive decomposition under ambient temperature and pressure without any external initiating source.
Examples include:

* ammonium chlorate
* organic azides

* metal azides
* peroxidized ethers
* benzoyl peroxide

Precautions

1. Materials should only be handled by knowledgeable and trained individuals.

2. Evaluate chemicals periodically to determine whether deterioration has occurred, and if so, dispose of properly by contacting ESH.

3. Check SDS for information on incompatibles for storage and chemical properties of materials handled.

4. Follow recommendations on SDS for personal protective equipment.

Class VIII

Forbidden explosives as defined in 49 CFR 173.51 or a Class A explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CFR 173.88.

Properties

Forbidden explosives are capable of detonation or explosive decomposition under ambient conditions, considered too dangerous for transportation.
Examples include:

Forbidden explosives:
* diethylene glycol dinitrate
* unstabilized nitroglycerine
* nitrocellulose

Class A explosives:
* TNT
* diazo-dinitrophenol
* mercury fulminate
* lead 2,4-dinitroresorcinate

Class B explosives:
* stabilized nitrocellulose
* stabilized nitroglycerin

Precautions

1. Materials should only be handled by experienced and properly equipped individuals.

LIGHT SENSITIVE MATERIALS

Materials which degrade in the presence of light, forming new compounds which can be hazardous, or resulting in conditions such as pressure build-up inside a container which may be hazardous.

Precautions

1. Store light-sensitive materials in a cool, dark place in amber colored bottles or other containers which reduce or eliminate penetration of light.

2. Date containers on receipt and upon opening, and dispose of surplus material after one year if unopened or 6 months if opened.

PROCEDURES FOR SAFE HANDLING OF COMPRESSED GASES

"Compressed Gas" is a generic term for three different types of gas products, compressed gases, liquefied compressed gases and cryogenic liquefied gases. A compressed gas is either:

1. A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 pounds per square inch (psi) at 70ºF;

2. A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130ºF regardless of the pressure at 70ºF; or

3. A liquid having a vapor pressure exceeding 40 psi at 100ºF as determined by ASTM D-323-72.

Compressed gases may be grouped into different hazard categories based upon their physical or health properties, or both. Any gas could be placed into more than one category. A gas could be corrosive, flammable, toxic, an oxidizer, or act as an asphyxiant by displacing oxygen. An additional hazard is due to the fact that gases are stored under high pressure.

Cryogens create unique hazards including fire, pressure, brittleness of material, and skin or eye burns upon contact with the liquid. Cryogens condense oxygen from air creating an oxygen rich atmosphere and increasing potential for fire if flammable or combustible materials and an ignition source are present. Pressure is a hazard because of the large explosion ratio from liquid to gas, causing pressure build up in containers. Many materials become brittle at extremely low temperatures. Brief bodily contact with materials at extremely low temperatures can cause burns similar to thermal burns.

Precautions

1. Never drop cylinders or permit them to strike each other violently.

2. The valve-protection cap should be left on each cylinder until it has been secured against a wall, bench, or placed in a stand and is ready to use.

3. Avoid dragging, rolling, or sliding cylinders, even for a short distance. They should be moved by using a cart with suitable racks, straps, chains, or stands to support cylinder during transport.

4. Never tamper with safety devices in valves or cylinders.

5. No part of cylinder should be subjected to temperature higher than 125ºF. A flame should never be permitted to come in contact with any part of a compressed gas cylinder.

6. Do not store full and empty cylinders together.

7. Bond and ground all cylinders, lines and equipment used with flammable compressed gases.

8. Use compressed gases only in well-ventilated areas. Toxic, flammable, and corrosive gases should be handled in a hood. Only small cylinders of toxic gases should be used.
9. When discharging gas into a liquid, a trap or suitable check valve should be used to prevent liquid from getting back into the cylinder or regulator.

10. When returning empty cylinders, close the valve before shipment, leaving some positive pressure in the cylinder. Replace the valve outlet and protective caps originally shipped with the cylinder. Mark or label the cylinder "empty" and store in designated area for return.

11. Before using cylinders, read all label information and SDS associated with the gas being used. Check SDS for required personal protective equipment and hazard information before use.

12. For flammable cryogens the precautions detailed in Procedures For Handling Flammable and Combustibles should be followed.

13. When handling cryogens always wear safety goggles and a face shield. If there is a splash or spray hazard, personal protective clothing should also include an impervious apron or coat, cuffless trousers, and high topped shoes. Gloves should be impervious. Pot holders could also be used.

14. Containers and systems containing cryogens should have pressure relief mechanisms.

15. Containers and systems should be capable of withstanding extreme cold without becoming brittle.

16. Always use smallest size cylinder required to perform the work.

17. 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.

RADIOACTIVE MATERIALS

Use of radioactive materials at Murray State University is strictly controlled. The procedures for handling radioactive materials are contained in the "Murray State University Radiation Safety Policy

and Procedures Manual". Contact the Radiation Safety Officer in ESH at extension 3480 if you are planning to use radioactive materials.

HEALTH HAZARDS

"Health hazard" refers to chemicals where 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. This term includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes. For a detailed discussion of industrial toxicology and information on health hazards associated with specific chemicals refer to Appendix E.

For many materials, hygienic standards have been established and action must be taken to assure personnel do not receive exposures in excess of these standards. These standards may be referred to as threshold limit values (TLVs) or permissible exposure limits (PELs).

The SDS will list the hygienic standard for the hazardous chemical or each component of a mixture. In addition, ESH has a complete listing of published TLVs and PELs and other works concerning the subject of industrial toxicology. If you would like to conduct a more thorough review of a particular compound, or if you would like an evaluation of the exposure to a specific material used in your work area, contact ESH.

The effects of exposure to toxic chemicals are either:

Acute- characterized by prompt or slightly delayed health effects, such as burns, allergic reactions, immediate damage to organs such as eyes.

Chronic- effects occur over a long period of time and are characterized by cumulative damage to organs including carcinogenic effects.

Protection from toxic hazards is provided by minimizing or eliminating the exposure. To minimize exposure it is necessary to determine the route by which exposure may occur, i.e., inhalation, skin contact, ingestion, injection.

Precautions

1. Know the hazards of the material you are using. Review the SDS and do additional research if necessary.

2. Use and store toxic chemicals only in established, clearly labeled designated control areas and in the smallest possible amounts.

3. Store and transport toxic chemicals in secondary containment trays, use in containment devices such as fume hoods and glove boxes.

4. Proper gloves and protective gear must be used. Non-disposable protective gear should be washed after use, disposable items must be discarded in marked containers inside the control area.

5. Be prepared for hazardous material emergencies and know what action to take. Assure necessary supplies and equipment are available for handling spills.

6. Wash hands and arms immediately after working with toxic materials.

7. Never eat, drink, smoke, apply cosmetics, or store food in areas where toxic substances are being used. Never smell or taste a hazardous chemical.

8. Contaminated washes and materials from experiments should be decontaminated chemically and disposed of properly. Normal lab work should not be resumed until work area is decontaminated.

GENERAL PROCEDURES FOR HANDLING CARCINOGENIC, REPRODUCTIVE AND HIGHLY TOXIC CHEMICALS

Follow the procedures described in this section when performing work with quantities greater than 10 milligrams (an American Chemical Society recommendation of any chemical covered by this section. Before working with any material check the SDS to determine whether the substances should be handled under these precautions.

Definitions

Select carcinogen – A substance capable of producing cancer in mammals. A chemical is considered to be a carcinogen if:

a. It is listed by the International Agency for Research on Cancer (IARC) as a Group 1, 2A, or 2B carcinogen.

b. It is listed as a carcinogen or potential carcinogen by the National Toxicology Program (NTP) in its Annual Report on Carcinogens.

c. OSHA regulates it as a carcinogen.

(A list of select carcinogens may be found in Appendix C under the NTP and IARC columns.)

Do not use the OSHA column on this list as the OSHA carcinogen list, use only the NTP and IARC columns plus these four compounds:

* ethyleneimine	* methyl chloromethyl ether
* a-naphthylamine	* 4-nitrobyphenyl

Reproductive toxin – A substance that can affect reproductive capabilities including chromosomal damage (mutations) and affects on fetuses (teratogenics). (See Appendix E)

Highly toxic chemical – A substance (poison) that falls within any of the following categories:

a. Median lethal dose (LD_{50}) administered orally is 50 mg or less.

b. LD_{50} administered by continuous contact is 200 mg or less.

c. Medial lethal concentration administered by inhalation is 200 ppm or less.

d. Any chemical whose properties are unknown.

For a list of highly toxic chemicals, see the P-listed materials in 401 KAR 31:040 or Appendix F.

Precautions

1. Establish designated areas such as fume hood, glove box, or entire lab by posting appropriate signs.

2. All work in quantities that exceed 10 mg shall be conducted within the designated area. Where possible, it is preferable that all work be conducted within designated areas.

3. Only those persons trained to work with these substances should work with them within the designated area and with prior approval of the supervisor.

4. Store these substances in locked areas under a slight negative pressure compared to the rest of the building and use only the smallest amount possible.

5. Decontaminate designated area when work is complete.

6. Personal protective equipment as recommended on the SDS must be worn when handling these substances.

7. Wastes must be disposed of in accordance with procedures detailed in the Hazardous Waste Section.

8. Properly label all containers.

9. Maintain records of the amounts of materials on hand, amounts used, and the names of workers involved.

10. Be prepared for accidents or spills. Assure that at least 2 people are present at all times if compound in use is highly toxic or of unknown toxicity.

GENERAL PROCEDURES FOR HANDLING ALLERGENS

A wide variety of substances can produce skin and lung hypersensitivity. Examples include:

* diazomethane
* nickel
* formaldehyde
* certain phenols
* chromium
* bichromates
* isocyanates

Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity.

Conduct aerosol producing procedures in a fume hood.

EMERGENCY RESPONSE

Plan in advance for an emergency. Some of the basic questions you should ask include:

- What are the possible emergencies that could occur during your work, e.g., fire, spill, high-level chemical exposure?
- Are systems available to alert you to an emergency situation, e.g. chemical monitoring systems?
- What supplies and equipment should you maintain in your area to assist you or emergency response personnel in the event of an emergency, e.g., eyewash and safety shower, spill control materials, personal protective equipment?
- What training do you need to handle an emergency in your area, e.g., emergency first aid or respirator use training?
- Is it safe for you to work alone?

CHEMICAL SPILLS

For a **small spill,** use an absorbent material that will neutralize the spill, if available. Spill kits are available from safety equipment supply companies or the following can be maintained:

- Trisodium phosphate (a soap)
- Sand (not for use with hydrofluoric acid)
- Sodium bicarbonate for acids
- Powdered citric acids for bases
- "Oil-Dri, "Zorb-All", "Speed=Dri", etc.
- Absorbent paper towels
- Bentonite, kitty litter, sand and soda ash mixture

A dustpan and brush should be used, and protective clothing (e.g., rubber gloves and goggles) should be worn. The area should be decontaminated with soap and water after clean-up. Residue should be placed in an appropriate container for waste collection. Contact ESH at 3480 for disposal information.

For a **large spill** see Murray State University's "Chemical Spill Response Plan" in Appendix D.

Mercury spill clean-up procedures.

This procedure is to be followed if a Mercury spill occurs.

I. Steps to take if a Mercury spill occurs.

A. Note any information that you can determine such as the size, source, and location.

B. Stay out of contact with the Mercury, and try to isolate the area keeping others from the area.

C. Notify designated lab supervisor.

II. These procedures are to be followed by designated lab supervisor.

A. Perform initial evaluation, taking in to account the extent of the spill, area contaminated by the spill, location of drains in the area, and potential hazards.

B. If spill is confined to a small area, and there is no potential for the drains to be contaminated, the spill may be cleaned up by individuals in the department who have received specific training in the handling of Mercury spills.
   1. Assemble necessary equipment to pick up spill.

      a. rubber gloves
      b. eye protection
      c. Mercury Absorbent and/or Hg Vac
      d. Mercury Sponges
      e. Scoop
      f. Recovery container
      g. Mercury suppressant towelettes

   2. Put on eye protection and rubber gloves, then search carefully for beads of Mercury, proceed to cover contaminated area with Mercury Absorbent and/or use Hg Vac.

   3. Scoop up all Mercury absorbent into recovery container. A second application may be necessary.

   4. Use Mercury suppressant towelettes for final decontamination of area, and for decontamination of equipment.

   5. Place Mercury suppressant towelettes into properly labeled waste container.

C. If the spill covers a large area, and/or the possibility of drain contamination exists, notify ESH at 3480.

FIRE RELATED EMERGENCIES

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

- Activate the building fire alarm system (fire pull station). If not available or operational, verbally notify persons in the building.
- Notify MSU Police by calling 911 on a landline phone.
- Isolate the area and evacuate the building by:
    - Shut down equipment in the immediate area, if possible.
    - Close doors to isolate the area.
    - Use a portable fire extinguisher to assist oneself or another to evacuate and to control a small fire, if possible.
- Provide the fire/police department with the details of the problem upon their arrival. Special hazard information you may know is essential.

If fire alarms are sounding in your building:

- Evacuate the building.
- Move at least 200 feet away from the building, go to the building's designated meeting place.
- Stay clear of driveways, sidewalks, and other access ways to the building.
- If you are a supervisor or person in charge, try to account for your employees and/or students and report any missing persons to the emergency personnel at the scene.
- Assist emergency personnel, as requested.
- Do not re-enter the building until advised to do so.

INJURY AND ILLNESS

Employees and students must notify their immediate supervisor or instructor of all illnesses and injuries related to exposure to hazardous chemicals.

If medical attention is required the employee or student should report to the Murray/Calloway County Hospital Emergency Room. Students should be accompanied by a friend, teaching assistant or instructor.

If transportation is necessary, the MSU Police should be contacted at 911.

Do not move a seriously injured person unless he/she is in further danger.

Give emergency and medical personnel the following information:

- Your name, location, and nature of the emergency
- The name of the chemical involved
- The amount involved
- Area of the body affected
- Symptoms

The supervisor or instructor must ensure that appropriate injury report forms are completed.

If you have any questions regarding injury and illness procedures, contact your supervisor.

MINOR FIRST-AID

First Aid Kits. First Aid Kits are not maintained by ESH. If a department places a first aid kit in an area, it is the responsibility of the department to maintain the kit with the proper supplies.

If a first aid kit is located in an area, it must be readily accessible. If the kit is not visible, the area where it is stored must be clearly marked.

Do not dispense or administer any medications, including aspirin.

Do not put any ointments or creams on wounds or burns. Use cool water.

The SDS contains special first aid information.

After giving first aid, call MSU Police for an ambulance (911), if necessary, to transport the victim to a medical facility for evaluation.

For specific first aid information, contact your supervisor.

TABLE I
CHEMICAL RESISTANCE OF PROTECTIVE CLOTHING MATERIALS

Chemical	**Resistance of Materials**					
	Neoprene	**Vinyl Plastic**	**Rubber Latex**	**Nitrile**	**Syn. Latex**	**Nat. Latex**
Alcohols	E	E	G	E	E	G
Austics	E	E	E	E	E	E
Chlorinated solvents	G	F	NR	E	G	NR
Ketones	G	NR	G	G	G	G
Petroleum Solvents	E	G	F	S	E	F
Organic Acids	E	E	E	E	E	E
Inorganic Acids	E	E	E	E	E	E
Non-Chlorinated Solvents	G	F	NR	G	G	NR
Insecticides	E	E	F	S	E	F
Inks	E	E	F	S	E	F
Formaldehyde	E	E	E	S	S	E
Acrylonitrile	E	G	E	S	E	E
Hydraulic Fluid	E	E	F	S	E	F
Carbon Disulfide	NR	F	G	F	NR	G
Paint Remover	F	F	NR	E	F	NR

S - Superior
E - Excellent
G – Good
F – Fair
NR – Not Recommended

APPENDIX A
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 SDS will contain information on incompatibilities.

The following list contains examples of some incompatible chemicals:

Chemical	Incompatible With
acetic acid	chromic acid, nitric acid, hydroxyl compounds, perchloric acid, peroxides, permanganates
acetylene	chlorine, bromine, copper, fluorine, silver, mercury
alkali metals	water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, the halogens, alcohols, aldehydes, ketones, acids
ammonia (anhydrous)	mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
ammonium nitrate	acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
aniline	nitric acid, hydrogen peroxide
arsenical material	any reducing agent
azides	acids
bromine	same as chlorine
calcium oxide	water
carbon, activated	calcium hypochlorite, all oxidizing agents
carbon tetrachloride	sodium
chlorates	ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials

chromic acid & chromium trioxide	acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general
chlorine	ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
chlorine dioxide	ammonia, methane, phosphine, hydrogen sulfide
copper	acetylene, hydrogen peroxide
cumene hydroperoxide	acids, organic or inorganic
cyanides	acids
flammable liquids	ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
fluorine	everything
hydrocarbons (such as butane, propane & benzene)	fluorine, chlorine, bromine, chromic acid, sodium peroxide
hydrocyanic acid	nitric acid, alkali
hydrofluoric acid	ammonia, aqueous or anhydrous
hydrogen peroxide	copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases
hydrogen sulfide	fuming nitric acid, oxidizing gases
hypochlorites	acids, activated carbon
iodine	acetylene, ammonia (aqueous or anhydrous), hydrogen
mercury	acetylene, fulminic acid, ammonia
nitrates	sulfuric acid

nitric acid (concentrated)	acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
nitrites	acids
nitroparaffins	inorganic bases, amines
oxalic acid	silver, mercury
oxygen	oils, grease, hydrogen, flammable liquids, flammable solids, flammable gases
perchloric acid	acetic anhydride, bismuth and its alloys, alcohol, paper, wood
peroxides, organic	acids (organic or mineral), avoid friction, store cold
phosphorus (white)	air, oxygen, alkalis, reducing agents
potassium	carbon tetrachloride, carbon dioxide, water (see alkali metals)
potassium chlorate	sulfuric and other acids
potassium permanganate	glycerin, ethylene glycol, benzaldehyde, sulfuric acid
selenides	reducing agents
silver	acetylene, oxalic acid, tartaric acid, ammonium compounds
sodium	carbon tetrachloride, carbon dioxide, water (see alkali metals)
sodium nitrite	ammonium nitrate and other ammonium salts
sodium peroxide	ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, methyl acetate, furfural

sulfides	acids
sulfuric acid	potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)
tellurides	reducing agents

Guide for Safety in the Chemical Laboratory, 2nd ed., Manufacturing Chemists' Association, Van Nostrand Reinhold: New York, 1972, pp. 215-217.

APPENDIX B
INDUSTRIAL TOXICOLOGY-OVERVIEW

Chemical Toxicology

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

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

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

Dose-Response Relationships

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 amount. The toxic potency of a chemical is thus ultimately defined by the relationship that is produced in a biological system.

Routes of Entry into the Body

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

- Inhalation: Absorption through the respiratory tract. Most important in terms of severity.
- Skin absorption.
- Ingestion: Absorption through the digestive tract. Can occur through eating or smoking with contaminated hands or in contaminated work areas.
- Injection: Can occur by accidental needle stick or puncture of skin with a sharp object.

Most exposure standards, Threshold Limit Values (TLVs) and Permissible Exposure Limits (PELs) are based on the inhalation route of exposure. They are normally expressed in terms of either parts per million (ppm) or milligrams per cubic meter (mg/m^3) concentration in air.

If a significant route of exposure for a substance is through skin contact, the TLV or PEL will have a "skin" notation. Examples are pesticides, carbon disulfide, carbon tetrachloride, dioxane, mercury, thallium compounds, xylene, and hydrogen cyanide.

Types of 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 are 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 are lead or mercury poisoning, and 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, gastrointestinal system, eyes, etc. Absorption does not necessarily occur. Examples are strong acids or alkalis and war gases.

Systemic refers to a site of action other than the point of contact and presupposes absorption has taken place. For example, an inhaled material may act on the liver. For example, arsenic affects the blood, nervous system, liver, kidneys and skin; benzene affects 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. Examples are heavy metals.

Substances in combination, meaning two or more hazardous materials present at the same time whose resulting effect is greater than the effect predicted based on the individual substances. This combined effect is called a **synergistic** or **potentiating** effect. An example is exposure to alcohol and chlorinated solvents.

Other Factors Affecting Toxicity

Rate of entry and route of exposure; that is, how fast the toxic dose is delivered and by what means.

State of health, medications, 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.

Physical Classification of Toxic Materials

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.

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/m^3). For a proper assessment of the toxic hazard, the size of the aerosol's particles is important. Particles above one micrometer tend to deposit in the upper respiratory tract. Below one micrometer particles enter the lung. Very small particles (<0.2μm) are generally not deposited.

Physiological Classification of Toxic Materials

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. Examples include:

***** ammonia
* hydrogen chloride
* halogens
* phosgene
* nitrogen dioxide
* arsenic trichloride
* alkaline dusts and mists
* hydrogen fluoride
* ozone
* diethyl/dimethyl sulfate
* phosphorus chlorides

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

* sulfur dioxide
* formaldehyde
* sulfuric acid
* iodine
* acetic acid
* formic acid
* acrolein

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 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.

Corrosives are chemicals which may cause visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact. Examples include:

* sulfuric acid
* potassium hydroxide

* chromic acid
* sodium hydroxide

Asphyxiates have the ability to deprive tissue of oxygen.

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

* nitrogen
* carbon dioxide
* nitrous oxide
* hydrogen

Chemical asphyxiates have as their specific toxic action rendering the body incapable of utilizing an adequate oxygen supply. They are toxic at very low concentrations (few ppm). Examples include:

* carbon monoxide
* cyanides

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

* carbon tetrachloride
* nitrosamines
* tetrachloroethane

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
* methyl mercury
* organic phosphorus insecticides
* manganese
* tetraethyl lead
* carbon disulfide
* thallium

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

* nitrites
* toluidine
* benzene
* aniline
* nitrobenzene

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 crystalline silica and asbestos. Other dusts can cause a restrictive disease called pneumoconiosis. Examples include:

* coal dust
* cotton dust
* wood dust

A **carcinogen** commonly describes any agent or mixture which contains an agent that can initiate or speed the development of malignant or potentially malignant tumors or malignant neoplastic proliferation of cells. Known human carcinogens include:

* asbestos
* alpha-napthylamine
* 3,3-dichlorobenzidine
* vinyl chloride
* ethylene oxide
* N-nitrosodimethylamine
* coat tar pitch volatiles
* 4-nitrobiphenyl
* methyl chloromethyl ether
* bis-chloromethyl ether
* inorganic arsenic
* 1,2-dibromo-3-chloropropane (DBCP)

A **mutagen** affects the chromosome chains of exposed cells. The effect is hereditary and becomes part of the genetic pool passed on to future generations. List of proven Teratogens and Mutagens include:

* Calcium arsenate
* benzene
* dimethylmercury
* 5-fluorouracil
* methotrexate
* methylmercury
* dinitrogen pentoxide

A **teratogen** (embryotoxic or fetotoxic agent) is an agent which interferes with normal embryonic development without damage to the mother or lethal effect on the fetus. Effects are not hereditary. Examples of **teratogenic agents** include:

* aminopterin
* androgenic hormones
* busulfan
* chlorobiphenyls
* coumarin anticoagulants
* cyclophosphamide
* dibromo dichloropropane
* diethylstilbestrol
* penicillamine
* 13-cis-retinoic acid
* tetracyclines
* diphenylhydantoin
* etretinate
* lead
* lithium
* methylaminopterin
* virus
* mercury, organic
* methimazole and scalp defects
* thalidomide
* trimethadione
* valproic acid

Example of teratogenic radiation include:

* ionizing radiation

Examples of **teratogenic infections** include:

* cytomegalovirus
* herpes virus hominis
* parvovirus B-19
* syphilis
* toxoplasmosis
* Venezuelan equine encephalitis
* rubella virus

A **sensitizer** causes a substantial proportion of exposed people to develop an allergic reaction in normal tissue after repeated exposure to the chemical. The reaction may be as mild as a rash (contact dermatitis) or as serious as anaphylactic shock. Examples include:

* epoxides
* nickel compounds
* poison ivy
* toluene diisocyanate
* chromium compounds
* chlorinated hydrocarbons
* formaldehyde
* amines

TARGET ORGAN EFFECTS

The following is a target organ categorization of effects which may occur, including examples of signs and symptoms and chemicals which have been found to cause such effects.

- **Hepatotoxics cause liver damage**

  Signs and symptoms: jaundice, liver enlargement

  Example chemicals: carbon tetrachloride, nitrosamines, chloroform, toluene, perchloroethylene, 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, Nitrobenzene

- **Hematopoietic agents decrease blood functions**

  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 of chemicals: silica, asbestos, nitrogen dioxide, ozone, hydrogen sulfide, Chromium, nickel, alcohol

- **Reproductive toxins affect the reproductive system (mutations and teratogenesis)**

  Signs and symptoms: birth defects, sterility

  Example of chemicals: lead, dibromo dichloropropane

- **Skin hazards affect the dermal layer of the body**

  Signs and symptoms: defatting of skin, rashes, irritation

  Example of chemicals: ketones, chlorinated compounds, alcohols, nickel, phenol, Trichloroethylene

- **Eye hazards affect the eye or vision**

  Signs and symptoms: conjunctivitis, corneal damage

  Example of chemicals: organic solvents, acids, cresol, quinone, hydroquinone, benzyl chloride, butyl alcohol, bases