PLAN REVIEW	
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LABORATORY STANDARD/CHEMICAL HYGIENE PROGRAM

Purpose

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

1. Chemical fume hood evaluations;
2. Establishment of standard operating procedures for routine and "high hazard" laboratory operations
3. Research protocol safety reviews
4. Employee exposure assessments
5. Medical consultations/exams
6. Employee training
7. Labeling of chemical containers and,
8. The management of chemical safety information sheets (Safety Data Sheets) and other safety reference materials.

The standard's intent is to ensure that laboratory employees are apprised of the hazards of chemicals in their work area, and that appropriate work practices and procedures are in place to protect laboratory employees from chemical health and safety hazards. The standard operating procedures (laboratory practices and engineering controls) recommended in this manual identify the safeguards that should be taken when working with hazardous materials.

These safeguards will protect laboratory workers from unsafe conditions in the vast majority of situations. There are instances, however, when the physical and chemical properties, the proposed use, the quantity used for a particular purpose or the

toxicity of a substance will be such that either additional, or fewer, controls might be appropriate to protect the laboratory worker. Professional judgment is essential in the interpretation of these standard operating procedures, and individual laboratories may modify these procedures to meet their specific uses and operational needs.

This document outlines how EllsworthPublic Schools is complying with each of the elements in OSHA's Laboratory Standard.

CHEMICAL HYGIENE PLAN RESPONSIBILITIES

Responsibility for chemical health and safety rests, at all levels, with «Lab», who has ultimate responsibility for chemical hygiene within all EllsworthPublic Schools buildings and must, along with other officials, provide continuing support for chemical safety.

Office of Environmental Health and Safety

A.) Responsibility:

The Office of Environmental Health and Safety (OEHS) is charged with the responsibility for control, review, monitoring and advise with respect to exposure to chemical, radiological, and biological agents used in research and teaching. The office does oversight and control of physical hazards in the workplace, including general and laboratory safety, and chemical waste disposal.

B.) Authority:

The Chemical Hygiene Officer («Lab») has the authority to stop any activity that is immediately hazardous to life or health. The primary function however, is to act in an advisory capacity to the individual departments, and help them provide a safe and healthful workplace.

The Chemical Hygiene Officer, who oversees and manages chemical hygiene for the labs has the following duties:

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

Work with department managers and supervisors to develop specific components of the Chemical Hygiene Plan. Special attention will be given to the safe procurement, use, and disposal of chemicals.

Assist department chemical hygiene officers/laboratory supervisors with conducting training sessions for all laboratory workers including supervisors, faculty, principal investigators, etc.

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

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

In addition, the Chemical Hygiene Officer will be responsible for knowing the contents of the relevant regulation (Occupational Exposures to Hazardous Chemicals in Laboratories, 29 CFR 1910.145) and conduct any required updating of the Chemical Hygiene Plan as regulations require.

Departments that will be required to implement the Chemical Hygiene Plan are as follows:

- Biology
- Chemistry
- Life Sciences

Each of these departments conduct laboratory work as defined in the OSHA Laboratory Standard.

Laboratory: means a facility where the laboratory use of hazardous chemicals occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

Any department not listed here will also be required to implement the Chemical Hygiene Plan if laboratory work is conducted.

Department Chemical Hygiene Officer/Laboratory Supervisor, has the responsibility as defined in the OSHA Laboratory Standard and the Chemical Hygiene Plan, to implement the Chemical Hygiene Plan thus ensuring compliance with the regulatory requirements and maintaining a safe work environment.

The **Department Chemical Hygiene Officer/Laboratory Supervisor** has the following duties:

- Ensure that all work is conducted in accordance with the department Chemical Hygiene Plan.

- Work with principal investigator to define the location of work areas where toxic substances potential carcinogens will be used, and ensure that the inventory of these substances is properly maintained.

- Work with the Office of Environmental Health and Safety and principal investigator to obtain, review, and approve standard operating procedures, detailing all aspects of proposed research activities that involve hazardous agents or practices not covered under the **General Standard Operating Procedures For Working With Chemicals.**

- Ensure that program and support staff receive instructions and training in safe work practices, use of personal protective equipment, and in procedures for dealing with accidents involving toxic substances.

    - Ensure that employees understand the training received.

    - Act as chair for those departments that have committees as noted above.

- Monitor the safety performance of the staff to ensure that the required safety practices and techniques are being employed.

- Work with principal investigators to arrange for workplace air samples, swipes or other tests to determine the amount and nature of airborne and/or surface contamination, inform employees of the results, and use data to aid in the evaluation and maintenance of appropriate laboratory conditions.

    - Assist OEHS when necessary.
    - Investigate accidents and report them to the Chemical Hygiene Officer.
    - Include procedures that will minimize the repetition of that type of accident.

- Report to the Chemical Hygiene Officer incidents that cause (1) personnel to be seriously exposed to hazardous chemicals or materials, such as through the inoculation of a chemical through cutaneous penetration, ingestion of a chemical, or probable inhalation of a chemical, or that (2) constitute a danger of environmental contamination.

- Make copies of the approved Chemical Hygiene Plan available to the program and support staff.

The **Principal Investigator** has the primary responsibility for chemical hygiene in the laboratory.

He/she is responsible for:

- Acquiring the knowledge and information needed to recognize and control chemical hazards in the laboratory.
- Selecting and employing laboratory practices and engineering controls that reduce the potential for exposure to hazardous chemicals to the appropriate level.
- Informing employees working in their laboratory of the potential hazards associated with the use of chemicals in the laboratory and instructing them in the safe laboratory practices, adequate controls, and procedures for dealing with accidents involving hazardous chemicals.
- Prepare a Standard Operating Procedure (SOP) for use of test substances when this use involves alternate procedures not specified in these guidelines.
- The SOP shall include a description of the alternate controls that will be used.
- Ensure that all personnel obtain the medical examinations and protective equipment necessary for the safe performance of their jobs.
- Ensure that action is taken to correct work practices and conditions that may result in the release of toxic chemicals.
- Supervising the performance of their staff to ensure the required chemical hygiene rules are adhered to in the laboratory.
- Defining hazardous operations, designating safe practices and selecting protective equipment.
- Ensuring appropriate controls (engineering and personal protective equipment) are used and in good working order.
- Obtaining approval, when required, prior to using particularly hazardous substances.
- Developing an understanding of the current legal requirements regulating hazardous substances used in his/her laboratory.

- Conducting formal laboratory inspections routinely to ensure compliance with existing laboratory SOP's.

- Preparing procedures for dealing with accidents that may result in the unexpected exposure of personnel, or the environment, to toxic substances.

- Properly disposing of unwanted and/or hazardous chemicals and materials.

- Documenting and maintaining compliance with all local, state, and federal requirements.

Laboratory workers are responsible for:

- Being aware of the hazards of the materials she/he is around or working with, and handling those chemicals in a safe manner;

- Planning and conducting each operation in accordance with established chemical hygiene procedures;

- Developing good chemical hygiene habits (chemical safety practices and procedures);

- Reporting unsafe conditions to his/her supervisor, or the department chemical hygiene officer.

The principal investigator and laboratory workers share responsibility for collecting, labeling and storing chemical hazardous waste properly, as well as informing visitors entering their laboratory of the potential hazards and safety rules/precautions.

Employees and Students are responsible for:

- Attending required training sessions and following all standard operating procedures of working in a laboratory.

- Wearing personal protective equipment as directed by the principal investigator.

- At a minimum, wearing safety glasses at all times when in the laboratory.

- Reporting to the teaching assistant, faculty member, or department chemical hygiene officer/laboratory supervisor any accidents that result in the exposure to toxic chemicals, and any action or condition that may exist which could result in an accident.

DEFINITIONS

Laboratory Definition

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

Hazardous Chemical Definition

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

The standard applies to all hazardous chemicals regardless of the quantity.

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

A chemical is a health hazard if there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Classes of health hazards include:

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

A chemical is considered a carcinogen or potential carcinogen if it is listed in any of the following publications (OSHA uses the term "select" carcinogen):

National Toxicology Program, Annual Report on Carcinogens (latest edition)
International Agency for Research on Cancer, Monographs (latest edition)
OSHA, 29 CFR 1910.1001 to 1910.1101, Toxic and Hazardous Substances

A chemical is considered hazardous according to the OSHA standard, if it is listed in

any of the following:

OSHA, 29 CFR 1910.1000 Table Z-1 through Z-3

Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, ACGIH (latest edition)The Registry of Toxic Effects of Chemical Substances, NIOSH (latest edition).

Over 600,000 chemicals are considered hazardous by the OSHA definition.

In most cases, the chemical container's original label will indicate if the chemical is hazardous. Look for key words like caution, hazardous, toxic, dangerous, corrosive, irritant, carcinogen, etc. Containers of hazardous chemicals acquired or manufactured before 1985 may not contain appropriate hazard warnings.

If you are not sure a chemical you are using is hazardous, review the Safety Data Sheet for the substance or contact your supervisor.

HAZARD IDENTIFICATION

Some laboratories may synthesize or develop new chemical substances on occasion. If the composition of the substance is known and will be used exclusively in the laboratory, the laboratory worker must label the substance and determine, to the best of his/her abilities, the hazardous properties (e.g. corrosive, flammable, reactive, toxic, etc.) of the substance. This can often be done by comparing the structure of the new substance with the structure of similar materials with known hazardous properties. If the chemical produced is of unknown composition, it must be assumed to be hazardous, and appropriate precautions taken. If a chemical substance is produced for another user outside this facility, the laboratory producing the substance is required to provide as much information as possible regarding the identify and known hazardous properties of the substance to the receiver of the material.

TRAINING & INFORMATION

Chemical Safety Training

All employees exposed, or potentially exposed, to hazardous chemicals while performing their laboratory duties must receive information and training regarding the standard, the chemical hygiene plan and laboratory safety. Our training program for laboratory workers consists of two parts: 1) introduction to the standard and to information not specific to the individual worksite to be conducted by the Office of Environmental Health and Safety, and 2) site specific elements of training to be conducted by the Principal Investigator or department chemical hygiene officer/laboratory supervisor. The training and information will be provided when an employee is initially assigned to a laboratory where hazardous chemicals are present,

and also prior to assignments involving new hazardous chemicals and/or new laboratory work procedures.

The training and information program will describe the:

- Physical and health hazards of various classes of laboratory chemicals handled;
- Methods/procedures for safely handling and detecting the presence or release of hazardous chemicals present in the laboratory;
- Appropriate response in the event of a chemical emergency (spill, overexposure, etc.);
- Chemical safety policies; and
- Applicable details of the Chemical Hygiene Plan (such as the standard operating procedures for using chemicals).

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

Every laboratory worker should know the location and proper use of available protective clothing and equipment, and emergency equipment/procedures. Information on protective clothing and equipment is contained further in this program.

Chemical Safety Information Sources

There are numerous sources of chemical safety information. These sources include:

- Special health and safety reference literature available in the Office of Environmental Health and Safety
- The labels found on containers of hazardous chemicals
- The substance's Safety Data Sheet and laboratory signs.

In addition, your supervisor is available to provide safety information. Each of these sources is now discussed in greater detail.

Safety Reference Literature

The Office of Environmental Health and Safety maintains a library of reference materials addressing chemical health and safety issues. One of the references contains all applicable chemical workplace exposure standards and recommended exposure levels. Another reference contains a copy of OSHA's laboratory safety standard and its appendices. Safety data sheets received from suppliers are available in your laboratory or a central area designated by your department.

Container Labeling

All containers of hazardous chemicals that could pose a physical or health hazard to an exposed employee must have a label attached. Labels on purchased hazardous chemicals must include:

- The common name of the chemical.
- The name, address and emergency phone number of the school responsible for the product.
- An appropriate hazard warning.

The warning may be a single word - "danger", "warning" and "caution" - or may identify the primary hazard, both physical (i.e., water reactive, flammable or explosive) and health (i.e., carcinogen, corrosive, or irritant).

Most labels will provide you with additional safety information to help you protect yourself while working with this substance. This includes protective measures to be used when handling the material, clothing that should be worn, first aid instructions, storage information and procedures to follow in the event of a fire, leak or spill.

If you find a container with no label, report it to your supervisor. You should also report labels that are torn or illegible so that the label can be replaced immediately. Existing labels on new containers of hazardous chemicals should never be removed or defaced, except when empty! If you use secondary working containers that will take more than one work shift to empty, or if there is a chance that someone else will handle the container before you finish it, you must label it. This is part of your responsibility to help protect co-workers.

Read the label each time you use a newly purchased chemical. It is possible the manufacturer may have added new hazard information or reformulated the product since your last purchase, and thus altered the potential hazards you face while working with the product.

All employees involved in unpacking chemicals are responsible for inspecting each incoming container to insure that it is labeled with the information outlined above. The principal investigators or department chemical hygiene officer/laboratory supervisors should be notified if containers do not have proper labels.

Laboratory Signs

Prominent signs of the following types should be posted in each laboratory:

- Telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers.
- Signs identifying locations for safety showers, eyewash stations, other safety

and first aid equipment, and exits
- Warnings at areas or equipment where special or unusual hazards exist.

CHEMICAL EXPOSURE ASSESSMENT

Regular environmental or employee exposure monitoring of airborne concentrations is not usually warranted or practical in laboratories because chemicals are typically used for relatively short time periods and in small quantities. However, sampling may be appropriate when a highly toxic substance is used regularly (3 or more separate handling sessions per week), used for an extended period of time (greater than 3 to 4 hours at a time), or used in especially large quantities.

Notify the Chemical Hygiene Officer if you are using a highly toxic substance in this manner.

The exposures to laboratory employees who suspect and report that they have been over exposed to a toxic chemical in the laboratory, or are displaying symptoms of overexposure to toxic chemicals, will also be assessed. The assessment will initially be qualitative and, based upon the professional judgment of the Chemical Hygiene Officer, may be followed up by specific quantitative monitoring. A memo, or report, documenting the assessment will be sent to the employees involved and their supervisors within fifteen days of receipt of the results. A copy will be stored in a central exposure records file maintained by the Office of Environmental Health and Safety.

Individual concerns about excessive exposures occurring in the laboratory should be brought to the attention of your supervisor or the Chemical Hygiene Officer immediately.

MEDICAL CONSULTATION & EXAMINATION

Employees who work with hazardous chemicals will be provided with an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, whenever an employee:

- Develops signs or symptoms associated with excessive exposure to a hazardous chemical used in their laboratory
- Exposed routinely above the action level (or in the absence of an action level, the applicable OSHA work place exposure limit) for an OSHA regulated substance;
- May have been exposed to a hazardous chemical during a chemical incident such as a spill, leak, explosion or fire and referred for medical follow up by the Chemical Hygiene Officer.

Individuals with life threatening emergencies should dial _____ for

emergency transport to the hospital. All accidents resulting in injuries that require medical treatment (including first aid) should be reported immediately to the Chemical Hygiene Officer. Medical examination/consultation visits (non-life threatening) will be handled by _____. Appointments can be arranged by contacting _____. Medical exams and consultations shall be done by or under direct supervision of a licensed physician at no cost to the employee. Where medical consultations or examinations are provided, the examining physician shall be provided with the following information:

- The identity of the hazardous chemical(s) to which the employee may have been exposed.
- The exposure conditions; and
- The signs and symptoms of exposure the laboratory employee is experiencing, if any.

CHEMICAL FUME HOOD EVALUATION

Every laboratory ventilation hood used for the control of air contaminants shall be tested once per year to assure that adequate airflow is being maintained to provide continued protection against employee over-exposure. The Office of Environmental Health and Safety is responsible for performing this testing. Laboratory hood airflow shall be considered adequate when the average face velocity equals a minimum of a 100 feet/minute with the hood sash at a working height (14 to 20 inches). Other local exhaust ventilation, such as instrument vents, will also be tested. The criteria for minimal acceptable flow shall be determined by the Office of Environmental Health and Safety. Results of laboratory ventilation tests shall be recorded and maintained by the Office of Environmental Health and Safety.

RESPIRATORY PROTECTION PROGRAM

EllsworthPublic Schools attempts to minimize employee respiratory exposure to potentially hazardous chemical substances through engineering methods (such as local exhaust ventilation) or administrative control. It is recognized, however, that for certain situations or operations, the use of these controls may not be feasible or practical. Under these circumstances, or while such controls are being instituted, or in emergency situations, the use of personal respiratory protective equipment may be necessary. A sound and effective program is essential to assure that the personnel using such equipment are adequately protected.

The District has adopted a written plan for using respirators. This plan outlines organizational responsibilities for the following respirator program components:

- Exposure assessment
- Respirator selection
- Medical approval and surveillance
- Fit testing

- User training;
- Inspection/repair
- Cleaning/disinfection and storage.

Each of these program components is required by OSHA's respiratory protection standard (29 CFR 1910.134) in all situations where respirators are used. If you are using a respirator and are not included in the respirator protection program, or have questions concerning the use of respirators or any of the program components, contact your Chemical Hygiene Officer.

RECORDKEEPING

All exposure assessments and occupational medical consultation/examination reports will be maintained in a secure area in accordance with OSHA's medical records rule (29 CFR 1910.20). Individuals may obtain copies or read their reports by making a request in writing to the Office of Environmental Health and Safety.

STANDARD OPERATING PROCEDURES AND GOOD WORK PRACTICES/PROCEDURES FOR CHEMICAL HANDLING

General Guidelines:

- Carefully read the label before using a chemical. The manufacturer's or supplier's Safety Data Sheet (MSDS) will provide special handling information.
- Be aware of the potential hazards existing in the laboratory and the appropriate safety precautions.
- Know the location and proper use of emergency equipment, the appropriate procedures for responding to emergencies, and the proper methods for storage, transport and disposal of chemicals within the facility.
- Do not work alone in the laboratory. If you must work alone or in the evening, let someone else know and have them periodically check on you.
- Label all secondary chemical containers with appropriate identification and hazard information (See Section I, Container Labeling).
- Use only those chemicals for which you have the appropriate exposure controls and administrative programs/procedures (training, restricted access, etc.).
- Always use adequate ventilation with chemicals. Operations using large quantities (500 milliliters) of volatile substances with workplace standards at or below 50 ppm should be performed in a chemical fume hood.
- Use hazardous chemicals and all laboratory equipment only as directed or for their intended purpose.
- Inspect equipment or apparatus for damage before adding a hazardous

chemical. Do not use damaged equipment.
- Inspect personal protective apparel and equipment for integrity or proper functioning before use.
- Malfunctioning laboratory equipment should be labeled or tagged "out of service" so that others will not inadvertently use it before repairs are made.
- Handle and store laboratory glassware with care. Do not use damaged glassware. Use extra care with Dewar flasks and other evacuated glass apparatus. Shield or wrap them to contain chemicals or fragments should implosion occur.
- Do not dispense more of a hazardous chemical than is needed for immediate use.

Personal Hygiene

- Remove contaminated clothing and gloves before leaving laboratory.
- Avoid direct contact with any chemical. Keep chemicals off your hands, face and clothing, including shoes.
- Never smell, inhale or taste a hazardous chemical.
- Wash thoroughly with soap and water after handling any chemical.
- Smoking, drinking, eating and the application of cosmetics is forbidden in laboratories where hazardous chemicals are used.
- Never pipet by mouth. Use a pipet bulb or other mechanical pipet filling device.

Housekeeping

- Keep floors clean and dry.
- Keep all aisles, hallways, and stairs clear of all chemicals. Stairways and hallways should not be used as storage areas.
- Keep all work areas, and especially work benches, clear of clutter and obstructions.
- All working surfaces should be cleaned regularly.
- Access to emergency equipment, utility controls, showers, eyewashes and exits should never be blocked.
- Wastes should be kept in the appropriate containers and labeled properly.
- Any unlabeled containers are considered wastes at the end of each working day.

WHEN NOT TO PROCEED WITHOUT REVIEWING SAFETY PROCEDURES

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

- A new procedure, process or test, even if it is very similar to older practices.
- A change or substitution of any of the ingredient chemicals in a procedure.
- A substantial change in the amount of chemicals used (scale up of experimental procedures) usually one should review safety practices if the volume of chemicals used increases by 200%.
- A failure of any of the equipment used in the process, especially safeguards such as chemical fume hoods.
- Unexpected experimental results (such as a pressure increase, increased reaction rates, unanticipated byproducts). When an experimental result is different from the predicted, a review of how the new result impacts safety practices should be made.
- Chemical odors, illness in the laboratory staff that may be related to chemical exposure or other indicators of a failure in engineered safeguards.
- The occurrence of any of these conditions should cause the laboratory employee to pause, evaluate the safety implications of these changes or results, make changes as necessary and proceed cautiously.

PROTECTIVE CLOTHING AND LABORATORY SAFETY EQUIPMENT

General Considerations:

Personal protective clothing and equipment should be selected carefully and used in situations where engineering and administrative controls cannot be used or while such controls are being established.

These devices are viewed as less protective than other controls because they rely heavily on each employee's work practices and training to be effective. The engineering and administrative controls that should always be considered first when reducing or eliminating exposures to hazardous chemicals include:

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

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

Your supervisor, other sections of this manual or the Chemical Hygiene Officer can assist you in determining which personal protective devices are required for each task. Remember, there is no harm in being overprotected. Appropriate personal protective equipment will be provided to employees.

Protection of Skin and Body

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

Normal clothing worn in the laboratory

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

Protective clothing

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

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

Chemical resistant gloves should be worn whenever the potential for contact with corrosive or toxic substances and substances of unknown toxicity exists. Gloves should

be selected on the basis of the materials being handled, the particular hazard involved, and their suitability for the operation being conducted. Before each use, gloves should be checked for integrity. Gloves should be washed prior to removal whenever possible to prevent skin contamination. Non-disposable gloves should be replaced periodically, depending on frequency of use and their resistance to the substances handled.

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

GLOVE TYPE SELECTION GUIDE

Chemical Family	Butyl Rubber	Neoprene	PVC (Vinyl)	Nitrile	Natural Latex
Acetates	G	NR	NR	NR	NR
Acids, inorganic	G	E	E	E	E
Acids, organic	E	E	E	E	E
Acetonitrile, Acrylonitrile	G	E	G	S	E
Alcohols	E	E	NR	E	E
Aldehydes	E	G	NR	S*	NR
Amines	S	NR	NR	F	NR
Bases, inorganic	E	E	E	E	E
Ethers	G	F	NR	E	NR
Halogens (liquids)	G	NR	F	E	NR
Inks	G	E	E	S	F
Ketones	E	G	NR	NR	G
NitroCompounds (Nitrobenzene,Nitromethane)	G	NR	NR	NR	NR
Oleic Acid	E	E	F	E	NR
Phenols	E	E	NR	NR	G
Quinones	NR	E	G	E	E
Solvents, Aliphatic	NR	NR	F	F	NR
Solvents, Aromatic	NR	NR	F	F	NR

*Not recommended for Acetaldehyde, use Butyl Rubber

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

Contact the Chemical Hygiene Officer for personal protection equipment selection assistance or information.

Protection of the Eyes

- Eye protection is required for all personnel and any visitors present in locations where chemicals are handled and a chemical splash hazard exists.

- Safety glasses, goggles and goggles with face shield should be worn in the laboratory based upon the physical state, the operation or the level of toxicity of the chemical used. Safety glasses effectively protect the eye from solid materials (dusts and flying objects) but are less effective at protecting the eyes from chemical splash to the face.

- Goggles should be worn in situations where bulk quantities of chemicals are handled and chemical splashes to the face are possible. Goggles form a liquid

proof seal around the eyes, protecting them from a splash.

- When handling highly reactive substances or large quantities of hazardous chemicals, corrosives, poisons, and hot chemicals, goggles with face shield should be worn.

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

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

COMPARISON CHART -- EYE PROTECTION DEVICES

TYPE	Front splash	Side splash	Front flying object	Side impact	Neck Face	Comfort	User Acceptance
Goggles	E	E	E	E	P	F	P
Glasses (no shields)	G	P	E	P	P	G	VG
Glasses (shields)	G	G	G	F	P	G	G
Face shields(various sizes)	G	G	G	F	P	G	G

E- Excellent
F- Fair
G-Good
P- Poor
VG- Very Good

SOURCE: ANSI Z87.1(1979) Occupational and Educational Eye and Face Protection, available from American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018

Protection Of The Respiratory System

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

- Use with adequate ventilation
- Avoid inhalation of vapors
- Use in a fume hood

- Provide local ventilation

Take appropriate precautions before using these substances. Controlling inhalation exposures via engineering controls (ventilation) is always the preferred method (See Section 2.3.5.1). As with other personal protective equipment, respiratory protection relies heavily on employee work practices and training to be effective.

Use of Respirators

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

Types of respiratory protective equipment include:

- 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 complete respiratory protection program as required by OSHA. If your work requires the use of a respirator, contact your supervisor or the Chemical Hygiene Officer. See Section 1.9 for additional information.

Laboratory Safety Equipment

Chemical Fume Hoods

In the laboratory the chemical fume hood is the primary means of controlling inhalation exposures. Hoods are designed to retain vapors and gases released within them, protecting the laboratory employee's breathing zone from the contaminant. This protection is accomplished by having a curtain of air (approximately 100 linear feet per minute) move constantly through the face (open sash) of the hood. Chemical fume hoods can also be used to isolate apparatus or chemicals that may present physical hazards to employees. The closed sash on a hood serves as an effective barrier to fires, flying objects, chemical splashes or spattering and small implosions and explosions. Hoods can also effectively contain spills that might occur during dispensing procedures particularly if trays are placed in the bottom of the hoods.

When using a chemical fume hood keep the following principles of safe operation in mind:

- Keep all chemicals and apparatus at least six inches inside the hood (behind sash).

- Hoods are not intended for storage of chemicals. Materials stored in them should be kept to a minimum. Stored chemicals should not block vents or alter air flow patterns.
- Keep the hood sash at a minimum height (4 to 6 inches) when not manipulating chemicals or adjusting apparatus within the hood.
- When working in front of a fume hood, make sure the sash opening is appropriate. This can be achieved by lining up to arrows placed on the sash door and hood frame. This sash opening will ensure an adequate air velocity through the face of the hood.
- Do not allow objects such as paper to enter the exhaust ducts. This can clog ducts and adversely affect their operation.

Follow the chemical manufacturer's or supplier's specific instructions for controlling inhalation exposures with ventilation (chemical fume hood) when using their products. These instructions are located on the products SDS and/or label. However, it should be noted that these ventilation recommendations are often intended for non-laboratory work environments and must be adapted to suit the laboratory environment as well as the specific procedure or process.

If specific guidance is not available from the chemical manufacturer or supplier, or if the guidance is inappropriate for the laboratory environment, contact the Chemical Hygiene Officer and/or review the hood use guidelines in the table below. These guidelines are based on information readily available on a chemical's MSDS:

1. applicable workplace exposure standards [Threshold Limit Values (TLV) or Permissible Exposure Limits (PEL)];
2. acute and chronic toxicity data (LD50 and specific organ toxicity); and
3. potential for generating airborne concentrations (vapor pressure).

<u>Eyewashes and safety showers</u>

Whenever chemicals have the possibility of damaging the skin or eyes, an emergency supply of water must be available. All laboratories in which bulk quantities of hazardous chemicals are handled and could contact the eyes or skin resulting in injury should have access to eyewash stations and safety showers. As with any safety equipment, these can only be useful if they are accessible, therefore:

- Keep all passageways to the eyewash and shower clear of any obstacle (even a temporarily parked chemical cart).
- Eyewashes should be checked routinely to be certain that water flows through it.
- Showers should be checked routinely to assure that access is not restricted and that the start chain is within reach.
- The flow through the safety showers should be tested periodically to

ensure sufficient flow (approximately 60 gallons per minute).

The Office of Environmental Health and Safety will check eyewashes and showers twice yearly to supplement the above work that is to be conducted by lab personnel.

Fire Safety Equipment

Fire safety equipment easily accessible to the laboratory must include a fire extinguisher (type ABC) and may include fire hoses, fire blankets, and automatic extinguishing systems.

CHEMICAL PROCUREMENT, DISTRIBUTION, AND STORAGE

Procurement

Before a new substance that is known or suspected to be hazardous is received, information on proper handling, storage, and disposal should be known to those who will handle it. It is the responsibility of the supervisor to ensure that the laboratory facilities in which the substance will be handled are adequate and that those who will handle the substance have received the proper training. The necessary information on proper handling of hazardous substances can be obtained from the Safety Data Sheets that are provided by the vendor. Because storage in laboratories is restricted to small containers, order small-container lots to avoid hazards associated with repackaging. No container should be accepted without an adequate identifying label as outlined in Section 1.5.2.2 of this manual.

Distribution

When hand-carrying open containers of hazardous chemicals or unopened containers with corrosive or highly acutely or chronically toxic chemicals, place the container in a secondary container or a bucket. Rubberized buckets are commercially available and provide both secondary containment as well as "bump" protection. If several bottles must be moved at once, the bottles should be transported on a small cart with a substantial rim to prevent slippage from the cart. Wherever available, a freight elevator should be used to transport chemicals from one floor to another.

Chemical Storage in the Laboratory

Carefully read the label before storing a hazardous chemical. The SDS will provide any special storage information as well as information on incompatibilities. 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:

Solids:
- oxidizers
- flammable solids (red phosphorus, magnesium, lithium)
- water reactive
- others

Liquids:
- acids
- oxidizers
- flammable/combustible
- caustics
- perchloric acid

Gases:
- toxic
- oxidizers and inert
- flammable

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

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

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

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

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

Conduct periodic inventories of chemicals stored in the laboratory (annually) and dispose of old or unwanted chemicals promptly in accordance with the facilities hazardous chemical waste program.

Assure all containers are properly labelled.

Chemical Storage - Chemical Stability

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

Special note: peroxide formers- Ethers, liquid paraffin's, and olefins form peroxides on exposure to air and light. Peroxides are extremely sensitive to shock, sparks, or other forms of accidental ignition (even more sensitive than primary explosives such as TNT). Since these chemicals are packaged in an air atmosphere, peroxides can form even though the containers have not been opened. Unless an inhibitor was added by the manufacturer, sealed containers of ethers should be discarded after one (1) year. Opened containers of ethers should also be discarded within one (1) year of opening. All such containers should be dated upon receipt and upon opening.

See Section 3.2, Highly Reactive Chemicals and High energy Oxidizers for additional information and examples of materials which may form explosive peroxides.

For additional information on chemical stability, contact your supervisor or the Chemical Hygiene Officer.

Chemical Storage - Incompatible Chemicals

Certain hazardous chemicals should not be mixed or stored with other chemicals because a severe reaction can take place or an extremely toxic reaction product can result. The label and SDS will contain information on incompatibilities. The following table contains examples of incompatible chemicals:

CHEMICAL	**KEEP OUT OF CONTACT WITH:**
Acetic Acid	Chromic acid, nitric acid hydroxyl compounds, ethylene, glycol, perchloric acid, peroxides, permanganates
Acetone	Concentrated nitric and sulfuric acid mixtures
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali Metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, and the halogens
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 materials, 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

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

Hydrocarbons

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, acetylene, ammonia (aqueous or anhydrous), hydrogen

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

Nitrites

Acids

Nitroparaffins

Inorganic bases, amines

Oxalic Acid

Silver, mercury

Oxygen

Oils, grease, hydrogen; flammable liquids, solids, or 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, alkali's, reducing agents

Potassium

Carbon tetrachloride, carbon dioxide, water

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

Sodium nitrite

Ammonium nitrate and other ammonium salts

Sodium Peroxide

Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, 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

Source: Manufacturing Chemists' Association, Guide for Safety in the Chemical Laboratory pp.215-217.

CHEMICAL SPILLS & ACCIDENTS

General Information

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

If the spill is too large for you to handle, is a threat to laboratory personnel or the public, or involves a highly toxic, or reactive chemical, call for assistance immediately.

Cleaning Up Chemical Spills

If you are cleaning up a small spill yourself, make sure that you are aware of the hazards associated with the materials spilled, have adequate ventilation (open windows, chemical fume hood on) and proper personal protective equipment (minimum - gloves, goggles, and lab coat). Consider all residual chemical and cleanup materials (adsorbent, gloves, etc.) as hazardous waste. Place these
materials in a sealed container (plastic bags) and store in a chemical fume hood. Contact the Office of Environmental Health and Safety for disposal instructions.

Minor Chemical Spill

- Alert people in immediate area of spill.
- Increase ventilation in area of spill (open windows, turn on hoods).

- Wear protective equipment, including safety goggles, gloves, and long-sleeve lab coat.
- Avoid breathing vapors from spill
- Use appropriate kit to neutralize and absorb inorganic acids and bases. Collect residue, place in container, and dispose as hazardous chemical waste.
- For other chemicals, use appropriate kit or absorb spill with vermiculite, dry sand, and diatomaceous earth or paper towels. Collect residue, place in container, and dispose as chemical waste.
- Clean spill area with water.

Major Chemical Spill

- Attend to injured or contaminated persons and remove them from exposure.
- Alert people in the laboratory to evacuate.
- If spilled material is flammable, turn off ignition and heat sources. Place other device (plastic bag) over spilled material to keep substance from volatilizing.
- Call Chemical Spill Emergency Response number _____Close doors to affected area.
- Have a person with knowledge of the incident and laboratory available to answer question from responding emergency personnel.

Mercury Spills

Use a vacuum line with an in-line dry trap attached to a tapered glass tube similar to a medicine dropper to pick up mercury droplets. Advanced Health, Safety and Security has a mercury vacuum available for personnel to use to handle mercury spills. Do not use a domestic or commercial vacuum cleaner. Cover small droplets in inaccessible areas with one of the following:

Powdered sulfur
Powdered zinc

Place residue in a labeled container and dispose of as hazardous chemical waste.

Alkali Metal Spills

Smother with powdered graphite, sodium carbonate, calcium carbonate or "Met-L-X", call the Chemical Hygiene Officer for assistance.

White Phosphorus

Smother with wet sand or wet "noncombustible" absorbent, call the Chemical Hygiene Officer for assistance.

PERSONAL CONTAMINATION AND INJURY

General Information

Know the locations of the nearest safety shower and eye wash fountain. Report all incidents and injuries to your supervisor. If an individual is contaminated or exposed to a hazardous material in your laboratory, do what is necessary to protect their life and health as well as your own. Determine what the individual was exposed to. The SDS will contain special first aid information.

- Do not move an injured person unless they are in further danger (from inhalation or skin exposure).
- A blanket should be used immediately to protect the victim from shock and exposure.
- Get medical attention promptly by dialing _____

Chemicals Spills on the Body

- Quickly remove all contaminated clothing and footwear.
- Immediately flood the affected body area in cold water for at least 15 minutes.
- Remove jewelry to facilitate removal of any residual material.
- Wash off chemical with water only. Do not use neutralizing chemicals, unguents, creams, lotions or salves.
- Get medical attention promptly.

It should be noted that some chemicals (phenol, aniline,) are rapidly adsorbed through the skin. If a large enough area of skin is contaminated, an adverse health effect (systemic toxicological reaction) may occur immediately to several hours after initial exposure depending on the chemical. If more than 9 square inches of skin area has been exposed to a hazardous chemical, seek medical attention after washing the material off the skin. If the incident involves hydrofluoric acid (HF), seek immediate medical attention. Provide the physician with the chemical name.

Chemical Splash in the Eye

- Irrigate the eyeball and inner surface of eyelid with plenty of cool water for at least 15 minutes.
- Use eyewash or other water source. Forcibly hold eyelids open to ensure effective wash.
- Check for and remove contact lenses.
- Get medical attention promptly.

Ingestion of Hazardous Chemicals

- Identify the chemical ingested.
- Call for an ambulance by dialing _____
- Call the Poison Information Center by dialing _____
- Cover the injured person to prevent shock.
- Provide the ambulance crew and physician with the chemical name and any other relevant information.
- If possible, send the container, SDS or the label with the victim.

Inhalation of Smoke, Vapors and Fumes

- Anyone overcome with smoke or chemical vapors or fumes should be removed to uncontaminated air and treated for shock.
- Do not enter the area if you expect that a life threatening condition still exists - oxygen depletion, explosive vapors or highly toxic gases (cyanide gas, hydrogen sulfide, nitrogen oxides, carbon monoxide).
- If CPR certified, follow standard CPR protocols.
- Get medical attention promptly.

Burning Chemicals on Clothing

- Extinguish burning clothing by using the drop-and-roll technique or by dousing with cold water, or use an emergency shower if it is immediately available.
- Remove contaminated clothing; however, avoid further damage to the burned area. If possible, send clothing with the victim.
- Remove heat with cool water or ice packs until tissue around burn feels normal to the touch.
- Cover injured person to prevent shock.
- Get medical attention promptly.

Actions to be Avoided During Emergencies

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

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

FIRE AND FIRE RELATED EMERGENCIES

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

- Notify the Fire Department dialing _____.
- Activate the building alarm (fire pull station). If not available or operational, verbally notify people in the building.
- Isolate the area by closing windows and doors and evacuate the building.
- Shut down equipment in the immediate area, if possible.
- Use a portable fire extinguisher to:
    1. assist one 's self to evacuate
    2. assist another to evacuate and control a small fire, if possible.

Provide the fire/police teams with the details of the problem upon their arrival. Special hazard information you might know is essential for the safety of the emergency responders.

If the fire alarms are ringing in your building

- You must evacuate the building and stay out until notified to return. Move up wind from the building and stay clear of streets, driveways, sidewalks and other access ways to the building.
- If you are a supervisor, try to account for your employees, keep them together and report any missing persons to the emergency personnel at the scene.

CHEMICAL WASTE DISPOSAL PROGRAM

Laboratory chemical waste must be disposed of in accordance with local, state, federal and requirements. These waste management practices are designed to ensure maintenance of a safe and healthful environment for laboratory employees and the surrounding community without adversely affecting the environment. This is accomplished through regular removal of chemical waste and disposal of these wastes in compliance with all regulations and policies. Specific guidance on how to identify, handle, collect, segregate, store and dispose of chemical waste is available from your supervisor or the Office of Environmental Health and Safety.

Remember:

- Hoods should not be used for storing of volatile chemicals.
- Drains should not be used for disposal of chemicals.
- Laboratory waste shall be disposed of in a timely manner.
- Waste materials should be accumulated in a designated storage area consistent with applicable regulations.

HEALTH AND SAFETY INFORMATION FOR WORK WITH CHEMICALS OF

SPECIFIC HAZARD CLASS

FLAMMABLE LIQUIDS

General Information

Flammable liquids are among the most common of the hazardous materials found in laboratories They are usually highly volatile (have high vapor pressures at room temperature) and their vapors, mixed with air at the appropriate ratio, can ignite and burn. By definition, the lowest temperature at which they can form an ignitable vapor/air mixture (the flash point) is less than 37.8 oC (100oF) and for several common laboratory solvents (ether, acetone, toluene, acetaldehyde) the flash point is well below that. As with all solvents, their vapor pressure increases with temperature and, therefore, as temperatures increase they become more hazardous.

For a fire to occur, three distinct conditions must exist simultaneously:

1. The concentration of the vapor must be between the upper and lower flammable limits of the substance (the right fuel/air mix).
2. An oxidizing atmosphere, usually air, must be available; and
3. A source of ignition must be present.

Removal of any of these three conditions will prevent the start of a fire. Flammable liquids may form flammable mixtures in either open or closed containers or spaces (such as refrigerators), when leaks or spills occur in the laboratory, and when heated.

Control strategies for preventing ignition of flammable vapors include removing all sources of ignition or maintaining the concentration of flammable vapors below the lower flammability limit by using local exhaust ventilation such as a hood. The former strategy is more difficult because of the numerous ignition sources in laboratories. Ignition sources include: open flames, hot surfaces, operation of electrical equipment, and static electricity.

The concentrated vapors of flammable liquids are heavier than air and can travel away from a source a considerable distance (across laboratories, into hallways, down elevator shafts or stairways). If the vapors reach a source of ignition, a flame can result that may flash back to the source of the vapor.

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

Special Handling Procedures

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

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

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

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

- Flammable substances should never be heated by using an open flame. Instead, use any of the following heat sources: steam baths, water baths, and oil baths, heating mantles or hot air baths.

- Do not distill flammable substances under reduced pressure.

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

- The volume of flammable liquids dispensed in small containers (not including safety cans) in the open areas of laboratories should not exceed 10 gallons in most laboratories. Never store glass containers of flammable liquids on the floor.

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

- Flammable liquids should not be stored or chilled in domestic refrigerators and freezers but in units specifically designed for this

purpose. It is acceptable to store or chill flammable in ultra-temperature units.

- If flammable liquids will be placed in ovens, make sure they are appropriately designed for flammable liquids (no internal ignition sources and/or vented mechanically).

HIGHLY REACTIVE CHEMICALS & HIGH ENERGY OXIDIZERS

General Information

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

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

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

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

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

Special Handling Procedures

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

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

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

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

Make sure that the reaction equipment is properly secured. Reaction vessels should be supported from beneath with tripods or lab jacks. Use shields or guards which are clamped or secured.

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

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

High energy oxidizers, such as perchloric acid, should only be handled in a wash down hood if the oxidizer will volatilize and potentially condense in the ventilation system. Inorganic oxidizers such as perchloric acid can react violently with most organic materials.

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

Labels on peroxide forming substances should contain the date the container was received, first opened and the initials of the person who first opened the container. They should be checked for the presence of peroxides before using, and quarterly while in storage (peroxide test strips are available). If peroxides are found, the materials should be decontaminated, if possible, or disposed of. The results of any testing should be placed on the container label. Never distill substances contaminated with peroxides. Peroxide forming substances that have been opened for more than one year should be discarded. Never use a metal spatula with peroxides. Contamination by metals can lead to explosive decompositions.

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

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

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

List of Shock Sensitive Chemicals

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

Acetylides of heavy metals
Heavy metal azides
Picramic acid
Aluminum ophrite explosive
Hexanite
Picramide
Amatol
Hexanitrodiphenylamine

Picratol
Ammonal
Hexanitrostilbene
Picric acid
Ammonium nitrate
Hexogen
Picryl chloride
Ammonium perchlorate
Hydrazinium nitrate
Picryl fluoride
Ammonium picrate
Hyrazoic acid
Polynitro aliphatic compounds
Ammonium salt lattice
Lead azide
Potassium nitroaminotetrazole
Butyl tetryl
Lead mannite
Silver acetylide
Calcium nitrate
Lead mononitroresorcinate
Silver azide
Copper acetylide
Lead picrate
Silver styphnate
Cyanuric triazide
Lead salts
Silver tetrazene
Cyclotrimethylenetrinitramine
Lead styphnate
Sodatol
Cyclotetramethylenetranitramine
Trimethylolethand
Sodium amatol
Dinitroethyleneurea
Magnesium ophorite
Sodium dinitro-orthocresolate
Dinitroglycerine
Wannitol hexanitrate
Sodium nitrate-potassium
Dinitrophenol
Mercury oxalate
Sodium picramate
Dinitrophenolates
Mercury tartrate
Styphnic acid

Dinitrophenyl hydrazine
Mononitrotoluene
Tetrazene
Dinitrotoluene
Nitrated carbohydrate
Tetranitrocarbazole
Dipicryl sulfone
Nitrated glucoside
Tetrytol
Dipicrylamine
Nitrated polyhydric alcohol
Trimonite
Erythritol tetranitrate
Nitrogen trichloride
Trinitroanisole
Fulminate of mercury
Nitrogen tri-iodide
Trinitrobenzene
Fulminate of silver
Nitroglycerin
Trinitrobenzoic acid
Fulminating gold
Nitroglycide
Trinitrocresol
Fulminating mercury
Nitroglycol
Trinitro-meta-cresol
Fulminating platinum
Nitroguanidine
Trinitronaphtalene
Fulminating silver
Nitroparaffins
Trinitrophenetol
Gelatinized nitrocellulose
Nitronium perchlorate
Trinitrophloroglucinol
Germane
Nitrourea
Trinitroresorcinol
Guanyl nitrosamino
Organic amine nitrates
Tritonal
guanyl-tetrazene
Organic nitramines
Urea nitrate
Guanyl nitrosaminoguanylidene-hydrazine

Organic peroxides

List of High Energy Oxidizers

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

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

List of Peroxide Formers

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

Acetal
Dimethyl ether
Sodium amide
Cyclohexene
Dioxane
Tetrahydrofuran
Decahydronaphthalene
Divinyl acetylene
Tetrahydronaphthalene
Diacetylene
Ether (glyme)
Vinyl ethers
Dicyclopentadiene

Ethylene glycol dimethyl ether
Vinylidene chloride
Diethyl ether
Isopropyl ether
Diethylene glycol
Methyl acetylene

COMPRESSED GASES

General Information

Compressed gases are unique in that they represent both a physical and a potential chemical hazard (depending on the particular gas). Gases contained in cylinders may be from any of the hazard classes described in this section (flammable, reactive, corrosive, or toxic). Because of their physical state (gaseous), concentrations in the laboratory can increase instantaneously if leaks develop at the regulator or piping systems, creating the potential for a toxic chemical exposure or a fire/explosion hazard. Often there is little or no indication that leaks have or are occurring. Finally, the large amount of potential energy resulting from compression of the gas makes a compressed gas cylinder a potential rocket or fragmentation bomb if the tank or valve is physically broken.

Special Handling Procedures

The contents of any compressed gas cylinder should be clearly identified. No cylinder should be accepted for use that does not legibly identify its contents by name. Color coding is not a reliable means of identification and labels on caps have no value as caps are interchangeable.

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

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

- Store as few cylinders as possible in your laboratory.
- Use only Compressed Gas Association standard combinations of valves and fittings for compressed gas installations. Always use the correct pressure regulator. Do not use a regulator adaptor.
- All gas lines leading from a compressed gas supply should be clearly labelled identifying the gas and the laboratory served.

- Place gas cylinders in such a way that the cylinder valve is accessible at all times. The main cylinder valve should be closed as soon as the gas flow is no longer needed. Do not store gas cylinders with pressure on the regulator. Use the wrenches or other tools provided by the cylinder supplier to open a valve if available. In no case should pliers be used to open a cylinder valve.

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

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

- Never bleed a cylinder completely empty. Leave a slight pressure to keep contaminants out (1 kPa or 25 psi). Empty cylinders should not be refilled in the laboratories unless equipped to prevent overfilling.

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

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

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

Special Precautions for Hydrogen

Hydrogen gas has several unique properties which make it potentially dangerous to work with. It has an extremely wide flammability range (LEL 4%, UEL 74.5%) making it easier to ignite than most other flammable gases. Unlike most other gases, hydrogen's temperature increases during expansion. If a cylinder valve is opened too quickly, the static charge generated by the escaping gas may cause it to ignite. Hydrogen burns with an invisible flame. Caution should therefore be exercised when approaching a suspected hydrogen flame. A piece of paper can be used to tell if the hydrogen is burning.

Hydrogen embrittlement can weaken carbon steel, therefore cast iron pipes and fittings shall not be used. Those precautions associated with other flammable substances also apply to Hydrogen
(see Section 3.1).

CORROSIVE CHEMICALS

General Information

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

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

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

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

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

Special Handling Procedures

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

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

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

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

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

CHEMICALS OF HIGH ACUTE & CHRONIC TOXICITY

General Information

Substances that possess the characteristic of high acute toxicity can cause damage after a single or short term exposure. The immediate toxic effects to human health range from irritation to illness and death. Hydrogen cyanide, phosgene, and nitrogen dioxide are examples of substances with high acute toxicity. The lethal oral dose for an average human adult for highly toxic substances range from one ounce to a few drops. The following procedures should be used when the oral LD50 of a substance in the rat or mouse is less than 50 milligrams per kilogram body weight for solid materials or non-volatile liquids and 500 mg/kg body weight for volatile liquids or gases. Oral LD50 data for the rat or mouse is listed in the substance's MSDS. The LD50 toxicity test is usually the first toxicological test performed and is a good indicator of a substance's acute toxicity.

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

substances' MSDS. If you have additional questions, contact the [FACILTIY NAME] Chemical Hygiene Officer.

Special Handling Procedures

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

Use these chemicals in a chemical fume hood or other appropriate containment device if the material is volatile or the procedure may generate aerosols (See guidelines for chemical fume hood use in (Section 2.3.5.1). If a chemical fume hood is used, it should be evaluated to confirm that it is performing adequately (a face velocity of at least 100 linear feet per minute (±20%)) with the sash at the operating height.

Store volatile chemicals of high acute or chronic toxicity in the cabinet under the hood or other vented area. Volatile chemicals should be stored in unbreakable primary or secondary containers or placed in chemically resistant trays (to contain spills). Nonvolatile chemicals should be stored in cabinets or in drawers. Do not store these chemicals on open shelves or counters.

Decontaminate working surfaces with wet paper towels after completing procedures. Place the towels in plastic bags and secure. Dispose of them in the normal trash.

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

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

If one or more of these substances are used in large quantities, on a regular basis (three or more separate handling sessions per week), or for long periods of time (4-6 hours) a qualitative and potentially quantitative exposure assessment should be performed. Contact the Chemical Hygiene Officer to perform this assessment.

Lab personnel of childbearing age should be informed of any known male and female reproductive toxins used in the laboratory. An employee who is pregnant, or planning to become pregnant, and who is working with potential reproductive toxins that might affect the fetus, should contact the Chemical Hygiene Officer to evaluate their exposure and inform her personal physician. The Chemical Hygiene Officer can assess potential exposures and work with the employee and laboratory supervisor, if necessary, to adjust work practices to minimize the potential risk.

REGULATED CHEMICALS

General Information

This section establishes supplemental work procedures to control the handling of substances that are known to exhibit unusual acute or long-term chronic health hazards (carcinogens, reproductive toxin and highly acutely toxic substances). This set of procedures applies (as indicated in Appendix A) to chemical carcinogens listed and regulated by the Department of Labor, Occupational Safety and Health Administration (OSHA), and of human carcinogens listed by the International Agency for Research on Cancer (IARC) and the National Toxicology Program (NTP).
Appendix A identifies under what conditions and for what substances the special handling procedures listed below should be used. Please note that a key component in controlling the most hazardous substances is the controlled distribution and use of these substances. In some instance special authorization is required before purchasing and using these substances.

Special Handling Procedures

Use these chemicals only in a chemical fume hood or other appropriate containment device (glove box). If a chemical fume hood is used, it should be evaluated to confirm that it is performing adequately (a face velocity of at least 100 linear feet per minute with the sash at the operating height).

Volatile chemicals should be stored in a vented storage area in an unbreakable, primary or secondary container or placed in a chemically resistant tray (to contain spills). Nonvolatile chemicals should be stored in cabinets or in drawers. Do not store these chemicals on open shelves or counters. Access to all of these chemicals should be restricted.

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

All procedures with these chemicals should be performed in designated areas. Other employees working in the area should be informed of the particular hazards associated with these substances and the appropriate precautions that are necessary for preventing exposures. All designated areas should be posted with a sign that reads:

WARNING
DESIGNATED AREA FOR HANDLING THE FOLLOWING
SUBSTANCES WITH HIGH ACUTE OR CHRONIC TOXICITY:
[list of substances - identify acute or chronic hazard]
[Example: Benzene - carcinogen]

AUTHORIZED PERSONNEL ONLY

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

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

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

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

Work surfaces on which these substances will be handled should be covered with an easily decontaminated surface (such as stainless steel) or protected from contamination with plastic trays or plastic backed paper. Call the Chemical Hygiene Officer for decontamination and disposal procedures; these will be substance specific. Materials that will be disposed of should be placed in plastic bags and secured.

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

Normal laboratory work should not be conducted in a designated area until it has been decontaminated or determined to be acceptable by the principal investigator or Chemical Hygiene Officer.

If one or more of these substances are used in large quantities, on a regular basis (three or more separate handling sessions per week), or for long periods of time (4-6 hours), a qualitative and potentially quantitative exposure assessment should be performed. Contact the Chemical Hygiene Officer to have this assessment performed. The Chemical Hygiene Officer in conjunction with a Health Center Physician will determine if it is appropriate to establish an ongoing medical surveillance program.

Lab personnel of childbearing age should be informed of any known male and

female reproductive toxins used in the laboratory. An employee who is pregnant, or planning to become pregnant, and who is working with potential reproductive toxins that might affect the fetus, should contact the Chemical Hygiene Officer to evaluate their exposure and inform her personal physician. The Chemical Hygiene Officer can assess potential exposures and work with the employee and laboratory supervisor, if necessary, to adjust work practices to minimize the potential risk.