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George G. Ishii
Cofacilitator and Division Safety Officer

INTRODUCTION

The Occupational Exposures to Hazardous Chemicals in Laboratories Standard, published by OSHA on January 31, 1990, requires the development and implementation of a written Chemical Hygiene and Safety Plan.

The plan must be a written plan which is readily available to employees, their representatives and, if necessary, representatives of OSHA. The Plan establishes two broad performance goals:

1. The Chemical Hygiene and Safety Plan must be "capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory," and capable of providing a safe working environment.

2. The Chemical Hygiene and Safety Plan must be "capable of keeping exposures below...Permissible Exposure Limits: For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR 1910, Subpart Z."

Laboratories vary widely in mission and structure. It is impossible to design a set of rules that will cover all possible hazards and occurrences. Some general guidelines are given in this plan that experience has shown to be useful for avoiding accidents or reducing injuries in the laboratory.

This plan must be a "living" document. It must be completed based on the best current knowledge and information and continually be reevaluated and updated as experience increases our knowledge.

A. Elements of the Plan

The Chemical Hygiene and Safety Plan has eight main elements:

1. Designation of responsible personnel

2. Standard Operating Procedures

3. Control measures

4. Hood and protective equipment performance

5. Circumstances where prior approval of an operation is required

6. Procedures for handling particularly hazardous substances

7. Provisions for medical consultation and examinations

8. Employee information and training

B. Chemical Hygiene Responsibilities

For the implementation of the Chemical Hygiene and Safety Plan, the Crime Lab Division must designate specific personnel responsible for the plan, including a Chemical Hygiene Officer from each of the Laboratories in the division, who together makeup the Chemical Hygiene and Safety Committee.

C. The Chemical Hygiene Officer

The person selected by the Laboratory Manager as the Chemical Hygiene and Safety Officer has primary responsibility for the Chemical Hygiene and Safety Plan.

The Chemical Hygiene and Safety Officer must be qualified, by training or experience, to provide guidance in the development and implementation of the provisions of the Chemical Hygiene and Safety Plan.

The Chemical Hygiene and Safety Officer's responsibilities are:

- Work with supervisors/lab managers and other employees to develop and implement appropriate chemical hygiene and safety policies and practices;
- Monitor procurement, use, storage, and disposal of chemicals used in the lab;
- Maintain appropriate audits at least annually;
- Help Lab Managers develop precautions and adequate facilities;
- Know the current legal requirements concerning regulated substances;
- Seek ways of improving the Chemical Hygiene and Safety Plan;
- Annually update the Chemical Hygiene and Safety Plan.

INTRODUCTION

Every person in the laboratory is responsible for chemical hygiene, from the Laboratory Manager to the people who conduct day-to-day operations in the labs.

The Chief of the Washington State Patrol has ultimate responsibility for chemical hygiene and safety within the Department and must, with other administrators, provide continuing support for chemical hygiene and safety. The Chief must ensure that an effective safety program is in place and show an obvious and continuing interest in the safety program.

The Crime Laboratory Division Commander is responsible for chemical hygiene and safety in that division. If appropriate, the Division Commander shall appoint a division safety officer.

The Laboratory Manager has overall responsibility for chemical hygiene in the laboratory including responsibility to:

- Ensure that workers know and follow the chemical hygiene and safety rules;
- Ensure that protective and emergency equipment is available and in working order and that appropriate training has been provided;
- Provide regular, formal chemical hygiene, safety, and housekeeping inspections, including routine inspections of emergency equipment;
- Know the current legal requirements concerning regulated substances;
- Determine the required levels of protective apparel and equipment;
- Ensure that facilities and training for use of any material being ordered are adequate.

The laboratory worker is responsible for planning and conducting each operation in accordance with the institutional chemical hygiene and safety procedures, and is required to develop good personal chemical hygiene habits and to review relevant MSDSs.

INTRODUCTION

Chemical hygiene and safety requires a coordinated effort on the part of all personnel. Under the Chemical Hygiene and Safety Plan, the following are some of the areas of responsibility that should be assigned to specific personnel, either to be performed by or under the supervision of the Laboratory Manager:

- Determine when exposure monitoring is necessary;
- Conduct exposure monitoring procedures;
- Provide technical assistance in complying with the Chemical Hygiene and Safety Plan;
- Assist with safety precautions for new projects and procedures;
- Monitor procurement of new chemicals and MSDSs;
- Monitor collection and disposal of chemical wastes;
- Remain current on regulations and legal requirements regarding chemicals used in this facility;
- Ensure availability of proper protective equipment as needed;
- Ensure that protective and control equipment is functioning properly;
- Perform regular chemical hygiene, safety, and housekeeping instruction;
- Perform routine inspections of emergency equipment;
- Ensure that proper signs and labels are provided and used;
- Inventory and monitor chemicals that are particularly hazardous (see Appendix E);
- Determine when a complaint of possible over-exposure should be referred for medical consultation;
- Determine when an exposure assessment is appropriate and conduct as needed.

I. STANDARD OPERATING PROCEDURES

While it is impossible to design a set of rules and procedures that will cover every possible hazard or situation, this section of the plan lists general standard operating procedures for good chemical hygiene under most circumstances.

A. Minimize All Chemical Exposures

1. The hazards of handling chemicals may be classified as physical or chemical.

   Physical hazards include fire, explosion, and electric shock. Other physical hazards arise from containment measures like compressed gas cylinders, cryogenic equipment, refrigerators, and glass apparatus.

   Chemical hazards are associated with their toxic effects and may be chronic or acute. Acute hazards produce prompt or only slightly delayed effects such as serious burns, inflammation, allergic responses, or damage to the eyes, lungs, or nervous system. Some chemicals require only small amounts to cause death or severe injury very quickly. Some chemicals, such as chlorine or ammonia, give considerable warning.

   Chronic hazards show the toxicological effects after a long delay or after exposure over long periods of time. These effects may involve cumulative damage to many different organs or parts of the body. Some can be reversed by the elimination of exposure to the chemical; but some are nearly irreversible, especially after there has been much damage. Carcinogenic effects are usually chronic effects.

   Many people who are not involved in laboratory operations may be exposed to chemical hazards--handling chemicals in evidence-receiving areas, storerooms, and stockrooms and transporting and disposing of them. These people must be warned to take actions to protect themselves from such hazards, and taught what to do in case of an emergency.

2. Guidelines to Minimize Exposure

   a. Laboratory workers must know and follow the rules and procedures in the Chemical Hygiene and Safety Plan.

   b. Always be alert to unsafe conditions and actions. Make sure they are corrected immediately. Someone else's accident can be as dangerous to you as any you might have.

   c. Think, act, and encourage safety so it becomes a habit.

   d. Always use common sense, good judgement, professional expertise, and safety awareness when it comes to hazardous chemicals. Practical jokes or horseplay cannot be tolerated at any time in the laboratory.

   e. Always avoid unnecessary exposure to chemicals by any route.

   f. Prevent quantities of chemical vapors or dust that might produce adverse toxic effects from entering the general laboratory atmosphere.

   g. Avoid working alone in a building or in a laboratory if the procedures being conducted are hazardous. Arrangements can be made between individuals working in separate laboratories to cross check periodically. Security guards may be asked to check on a laboratory worker. Experiments known to be hazardous should not be done by a worker who is alone in the laboratory.

   h. Inspect gloves carefully before each use for discoloration, punctures, and tears. Glove materials will eventually be permeated by chemicals. Discard them correctly when they become contaminated. Never use damaged gloves.

3. Do Not Underestimate Risk

   When dealing with chemicals, even if substances have no known significant hazards, always observe good laboratory practices. Minimize exposure by working in an exhaust hood; wear eye

and hand protection and a laboratory coat. If substances have special hazards, take special precautions. Consult any appropriate regulations to be advised of the necessary approvals, training, working conditions, monitoring, record keeping, and medical surveillance that might apply.

Chemical reactions involving two or more substances may form reaction products that are significantly more toxic than the starting reactants. Always assume that any mixture will be more toxic than its most toxic component and that all substances of unknown toxicity are toxic.

All new and untested chemicals should be treated as though they are toxic until proven otherwise. Since chemical research is often concerned with new molecular structures, laboratory workers should try to anticipate the toxicity, acute or chronic, of a new substance. This is an important part of planning all research involving new chemicals.

It is important for all laboratory workers to understand the types of toxicity, to know the routes of exposure, and to recognize the major classes of toxic and corrosive chemicals.

B. Routes of Exposure

Exposure to chemicals may occur by the following routes:

- Inhalation
- Ingestion
- Contact with skin and eyes
- Injection

1. Inhalation

Inhalation of toxic vapors, mists, gases, or dusts can produce poisoning by absorption through the mucous membrane of the mouth, throat, and lungs and can seriously damage these tissues by local action. Inhaled gases or vapors may pass rapidly into the capillaries of the lungs and be carried into the circulatory system. This absorption can be extremely rapid. The rate will vary with the concentration of the toxic substance, its solubility in tissue fluids, the depth of respiration, and the amount of

blood circulation; which means that it will be much higher when the person is active than when he or she is at rest.

The degree of injury resulting from exposure to toxic vapors, mists, gases, and dusts depends on the toxicity of the material and its solubility in tissue fluids, as well as on its concentration and the duration of exposure. Chemical activity and the time of response after exposure are not necessarily a measure of the degree of toxicity. Several chemicals (e.g., mercury and its derivatives) and some of the common solvents (benzene) are cumulative poisons that can produce body damage through exposure to small concentrations over a long period of time.

The American Conference of Governmental Industrial Hygienists (ACGIH) produces annual lists of Threshold Limit Values (TLVs) and Short Term Exposure Limits (STELs) for common chemicals used in laboratories. These values are guides, not legal standards, and are defined as follows:

- *TLV* Time-weighted average concentration for a normal 8-hour workday to which nearly all workers may be repeatedly exposed without adverse effect.

- *STEL* Maximum concentration to which workers can be exposed for periods up to 15 minutes. Such exposures should be limited to no more than four per day with periods of at least 60 minutes each between exposures. The total time-weighted exposures per day should not exceed the TLV value.

Most of the 1968 TLVs were adopted by OSHA in 1972 as legal Permissible Exposure Levels (PELs). The basis for selection of the TLVs appears to be more secure than the justification for the STELs. The TLVs provide a useful estimate of how much ventilation may be needed in laboratories where the occupants typically spend most of their working time.

However, because of the many factors influencing toxicity, each situation should be evaluated individually and the TLVs used as guidelines rather than as fine lines between safe and dangerous concentrations.

The best way to avoid exposure to toxic vapors, mists, gases, and dusts is to prevent the escape of such materials into the working atmosphere and to ensure adequate ventilation by the use of exhaust hoods and other local ventilation. Chemicals of unknown toxicity should not be smelled.

The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices. Chemicals should not be smelled. Operations such as running reactions, heating or evaporating solvents, and the transfer of chemicals from one container to another should normally be performed in a hood. Especially toxic or corrosive exit gases should be passed through scrubbers or adsorption trains. Toxic substances and laboratory apparatus that may discharge toxic vapors must be stored in areas fitted with ventilation. If auxiliary local ventilation is not practical during measurement or storage, samples should be kept in containers.

2. Ingestion

Many of the chemicals used in the laboratory are extremely dangerous if they enter the mouth and are swallowed.

The relative acute toxicity of a chemical can be evaluated by determining its LD50, which is defined as the quantity of material that, when ingested or applied to the skin in a single dose, will cause the death of 50 percent of the test animals. It is expressed in grams or milligrams per kilogram of body weight. In addition, many chemicals may damage the tissues of the mouth, nose, throat, lungs, and gastrointestinal tract and produce systemic poisoning if absorbed through the tissues.

To prevent entry of toxic chemicals into the mouth, laboratory workers should wash their hands before eating, smoking, or applying cosmetics; immediately after use of any toxic substance; and before leaving the laboratory. Food and drink should not be stored or consumed in areas where chemicals are being used nor should cigarettes, cigars, or pipes be used in such areas; chemicals should not be tasted; and pipetting and siphoning of liquids should never be done by mouth.

3. Contact With Skin and Eyes

Contact with the skin is a frequent mode of chemical injury. A common result of skin contact is a localized irritation; but an appreciable number of materials are absorbed through the skin with sufficient rapidity to produce systemic poisoning. The main portals of entry for chemicals through the skin are the hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the outer layers of the skin. The follicles and glands are abundantly supplied with blood vessels, which facilitates the absorption of chemicals into the body.

Contact of chemicals with the eyes is of particular concern because these organs are so sensitive to irritants. Few substances are innocuous in contact with the eyes; most are painful and irritating, and a considerable number are capable of causing burns and loss of vision. Alkaline materials, phenols, and strong acids are particularly corrosive and can cause permanent loss of vision. Also, eyes are very vascular and provide for rapid absorption of many chemicals.

Skin and eye contact with chemicals should be avoided by use of appropriate protective equipment. All persons in the laboratory should wear safety glasses as needed. Face shields, safety goggles, shields, and similar devices provide better protection for the eyes. Protection against skin contact may be obtained by use of gloves, laboratory coats, tongs, and other protective devices. Spills should be cleaned up promptly in accordance with the Spill Control Plan (see Appendix B).

In the event of skin contact, the affected areas should be flushed with water and medical attention should be sought if symptoms persist. In the event of eye contact, the eye(s) should be flushed with water for 15 minutes and medical attention should be sought whether or not symptoms persist.

4. Injection

Exposure to toxic chemicals by injection may occur in the Crime Laboratory. It can inadvertently occur through mechanical injury from glass or metal contaminated with chemicals or when chemicals are handled in syringes.

II. THE CHEMICAL HYGIENE PROGRAM

The Chemical Hygiene Program must be designed to minimize exposures. It must be a regular, on-going effort, not a standby or short-term activity. The program recommendations should be followed by all laboratory workers. Everyone must learn to work with and to accept the responsibility for the appropriate use of hazardous substances. The worker must learn to think about possible hazards and seek information and advice before starting any new experiment or procedure.

A. Planning

Safety is everyone's responsibility. Know the safety rules and procedures that apply to the work being done. Determine the potential hazards (physical, chemical, biological) and appropriate safety precautions before beginning any new operation. Get information and advice about hazards, plan appropriate protective procedures, and plan the positions of equipment before starting any new operation.

B. Beware of the PELs and TLVs

Do not exceed the Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists. Control measures should be designed and utilized to prevent exposures exceeding these guidelines.

C. Unattended Operations

Leave the lights on and place an appropriate sign on the door. Take the proper precautions for containment of toxic substances in case a utility service, such as cooling water, should fail during an unattended operation.

D. Glassware

Use equipment only for its designed purpose. Handle and store laboratory glassware with care to avoid damage or breakage. Use extra care with Dewar flasks and other evacuated glass apparatus. Shield or wrap them to contain chemicals and fragments should implosion occur. Repair or discard any damaged items. Use

adequate hand protection when inserting glass tubing into rubber stoppers or corks or when placing rubber tubing on glass hose connections.

Proper instruction should be received in the use of glass equipment designed for specialized tasks that may present unusual risks for the first time user.

Position and clamp reaction apparatus thoughtfully in order to permit manipulation without the need to move the apparatus until the entire reaction is completed. Combine reagents in appropriate order, and avoid adding solids to hot liquids.

E. Personal Hygiene

Contamination of food, drink, and smoking materials is a potential route for exposure to toxic substances. Food should be stored, handled, and consumed in an area free of hazardous substances. DO NOT eat, drink, smoke, or apply cosmetics where (or near where) chemicals or evidence are present or where laboratory analyses involving chemicals are being carried out. Food and beverages are allowed only in areas designated by the Laboratory Manager. Wash hands before doing any of these activities. Wash hands before using sanitary facilities after being in areas where evidence, chemicals, or hazardous materials are used or stored. Wash hands and arms immediately after handling any toxic or hazardous substance. Wash well before leaving the laboratory area. Do not use solvents on the skin.

Do not store food or beverages in laboratory refrigerators other than those specifically designated for food storage. Do not use glassware, utensils, or sinks which are used in laboratory operations to wash food items.

F. Personal Protection

Personnel must know the types of protective equipment available and use the proper type for each job. Everyone, including visitors, must wear the appropriate eye protection as necessary.

Never enter a laboratory without the appropriate eye protection. Use protective clothing, face shields, gloves, and other special clothing or footwear as needed.

If there is significant contamination, remove laboratory coats or other protective apparel immediately.

Use appropriate respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls. Inspect the respirator before use.

Specific requirements for selection and use of respiratory protection are listed in the laboratory's written respirator program (see Appendix C). Personnel must be properly trained before using any respiratory equipment.

Personnel must know the location and use of emergency equipment, how to obtain additional help in an emergency, and must be familiar with emergency procedures.

1. Personal Apparel

   Confine long hair and loose clothing. Do not wear loose (dangling neckties, too-large lab coats, etc...), skimpy, or torn clothing. Loose or torn clothing could get caught in apparatus or on instruments. Skimpy clothing offers little protection if there is a chemical splash.

   Tuck away or remove loose or dangling jewelry. Rings may react with chemicals. Rings should also be removed when working around equipment with moving parts.

   A protective laboratory coat or apron and appropriate shoes should be worn at all times in the laboratory and in buildings where chemicals are used or stored. Lab coats should be removed before eating or leaving the laboratory.

2. Eye Protection

It is very important that each operation be analyzed to ensure that adequate eye protection is used. When operations that involve potential hazard to the eyes are performed (such as handling unusually corrosive chemicals) more complete eye protection than spectacles should be worn. It is the responsibility of the laboratory supervisor to determine the level of eye protection required and to enforce eye-protection rules. Special precautions should be taken if contact lenses are worn in the laboratory.

Forms of eye protection that may be required for a particular operation include the following:

a. Goggles

Goggles are not intended for general use. They are intended for wear when there is danger of splashing chemicals or flying particles. For example, goggles should be worn when working with glassware under reduced or elevated pressure and when glass apparatus is used in combustion or other high-temperature operations. Impact-protection goggles have screened areas on the sides to provide ventilation and reduce fogging of the lens. They do not offer full protection against chemical splashes. Splash goggles ('acid goggles' or face shields) that have splash-proof sides should be used when protection from harmful chemical splash is needed.

b. Face Shields

Goggles offer little protection to the face and neck. Full-face shields that protect the face and throat should always be worn when maximum protection from flying particles and harmful liquids is needed; for full protection, safety glasses should be worn with face shields. A face shield or mask may be needed when a vacuum system (which may implode) is used or when a reaction that has a potential for mild explosions is conducted.

c. Specialized Eye Protection

There are specific goggles and masks for protection against laser hazards, ultraviolet, or other intense light sources, as well as glassblowing goggles and welding masks and goggles. The laboratory supervisor should determine whether the task being performed requires specialized eye protection and insist on the use of such equipment if it is necessary.

3. Gloves

Skin contact is a potential source of exposure to toxic materials. It is important that the proper steps be taken to prevent such contact.

a. Proper protective gloves (and other protective clothing, when necessary) should be worn whenever the potential for contact with corrosive or toxic materials and materials of unknown toxicity exists.

b. Gloves should be selected on the basis of the material being handled, the particular hazard involved, and their suitability for the operation being conducted.

c. Before each use, gloves should be inspected for discoloration, punctures, and tears.

d. Before removal, gloves should be washed appropriately. *NOTE: Some gloves (e.g., leather and polyvinyl alcohol) are water permeable.*

e. Glove materials are eventually permeated by chemicals. However, they can be used safely for limited time periods if specific use and glove characteristics (i.e., thickness and permeation rate and time) are known. Some of this information can be obtained from glove manufacturers, or the gloves used can be tested for breakthrough rates and times.

f. Gloves should be replaced periodically, depending on frequency of use and permeability to the substance(s) handled. Gloves obviously contaminated (if impermeable to water) should be rinsed and then carefully removed.

g. Gloves should be worn whenever it is necessary to handle corrosive materials, rough or sharp-edged objects, very hot or very cold materials, or whenever protection is needed against accidental exposure to chemicals. Gloves should not be worn around moving machinery. Many different types of gloves are commercially available.

(1) Leather gloves may be used for handling broken glassware, for inserting glass tubes into rubber stoppers, and for similar operations where protection from chemicals is not needed.

(2) There are various compositions and thicknesses of rubber gloves. Common glove materials include neoprene, polyvinyl chloride, nitrile, and butyl and natural rubbers. These materials differ in their resistance to various substances. [Specific information on this topic is often available from glove manufacturers' catalogs (although such data are usually only qualitative); example information is given in the following table.] Rubber gloves should be inspected before each use. Periodically, an inflation test, in which the glove is first inflated with air and then immersed in water and examined for the presence of air bubbles, should be conducted.

(3) Insulated gloves should be used when working at temperature extremes. Various synthetic materials such as Nomex and Kevlar can be used briefly up to 1000 degrees Fahrenheit. Gloves made with these materials or in combination with other materials such as leather are available. It is best not to use gloves made either entirely or partly of asbestos, which is regulated as a carcinogen under OSHA, although such gloves probably do not present a great hazard.

(4) Specialized gloves are manufactured for electrical linesmen, welders, and others. It is the responsibility of the laboratory supervisor to determine whether specialized hand protection is needed for any operation and to ensure that needed protection is available.

RESISTANCE TO CHEMICALS OF COMMON GLOVE MATERIALS				
KEY: E = Excellent G = Good F = Fair P = Poor	Latex/ Natural Rubber	Neoprene	Nitrile	Vinyl
Acetaldehyde	G	G	E	G
Acetic acid	E	E	E	E
Acetone	G	G	G	F
Acrylonitrile	P	G	-	F
Ammonium hydroxide(sat)	G	E	E	E
Aniline	F	G	E	G
Benzaldehyde	F	F	E	G
Benzene[a]	P	F	G	F
Benzyl chloride[a]	F	P	G	P
Bromine	G	G	-	G
Butane	P	E	-	P
Butyraldehyde	P	G	-	G
Calcium hypochlorite	P	G	G	G
Carbon disulfide	P	P	G	F
Carbon tetrachloride[a]	P	F	G	F
Chlorine	G	G	-	G
Chloroacetone	F	E	-	P
Chloroform[a]	P	F	G	P
Chromic acid	P	F	F	E
Cyclohexane	F	E	-	P
Dibenzyl ether	F	G	-	P
Dibutyl phthalate	F	G	-	P
Diethanolamine	F	E	-	E
Diethyl ether	F	G	E	P
Dimethyl sulfoxide[b]	-	-	-	-
Ethyl acetate	F	G	G	F
Ethylene dichloride[a]	P	F	G	P
Ethylene glycol	G	G	E	E
Ethylene trichloride[a]	P	P	-	P
Fluorine	G	G	-	G
Formaldehyde	G	E	E	E
Formic acid	G	E	E	E
Glycerol	G	G	E	E

RESISTANCE TO CHEMICALS OF COMMON GLOVE MATERIALS				
KEY: E = Excellent G = Good F = Fair P = Poor	Latex/ Natural Rubber	Neoprene	Nitrile	Vinyl
Hexane	P	E	-	P
Hydrobromic acid (40%)	G	E	-	E
Hydrochloric acid (conc)	G	G	G	E
Hydrofluoric acid (30%)	G	G	G	E
Hydrogen Peroxide	G	G	G	E
Iodine	G	G	-	G
Methylamine	G	G	E	E
Methyl cellosolve	F	E	-	P
Methyl chloride*	P	E	-	P
Methyl ethyl ketone	F	G	G	P
Methylene chloride*	F	F	G	F
Monoethanolamine	F	E	-	E
Morpholine	F	E	-	E
Naphthalene*	G	G	E	G
Nitric acid (conc)	P	P	P	G
Perchloric acid	F	G	F	E
Phenol	G	E	-	E
Phosphoric acid	G	E	-	E
Potassium hydroxide(sat)	G	G	G	E
Propylene dichloride*	P	F	-	P
Sodium hydroxide	G	G	G	E
Sodium hypochlorite	G	P	F	G
Sulfuric acid (conc)	G	G	F	G
Toluene*	P	F	G	F
Trichloroethylene*	P	F	G	F
Tricresyl phosphate	P	F	-	F
Triethanolamine	F	E	E	E
Trinitrotoluene	P	E	-	P

(a) Aromatic and halogenated hydrocarbons will attack all types of natural and synthetic glove materials. Should swelling occur, the user should change to fresh gloves and allow the swollen gloves to dry and return to normal.
(b) No data on the resistance to dimethyl sulfoxide of natural rubber, neoprene, nitrile rubber, or vinyl materials are available; the manufacturer of the substance recommends the use of butyl rubber gloves.

G. Special Situations

1. Prior Approval

Some laboratory operations require prior approval from the supervisor before they are carried out. The supervisor must be notified of the following:

a. If there is a substantial change in the process or amount of chemicals being used. For example, safety practices should be reviewed if the volume of chemicals is increased by 20 to 25 percent.

b. When there is a failure of any of the equipment used in the process, especially safeguards such as fume hoods or clamp apparatus.

c. When members of the laboratory staff suspect exposure, smell chemicals, or otherwise suspect a failure of engineered safeguards.

d. For certain unattended operations.

e. If novel techniques or nonroutine procedures are to be used.

f. Situations requiring prior approval for a procedure may also require a hazard review. The review is conducted by a group of senior lab personnel who consider the proposed activity and discuss the safety aspects of the procedure with the personnel involved. The procedure will be approved only after the safety questions are adequately answered and all are satisfied that it can proceed safely. A hazard review will generally be required before conducting a procedure that is new and complex or is suspected to be especially hazardous.

2. Particularly Hazardous Substances

Particularly hazardous materials, such as select carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity, require special procedures and precautions.

In general, procedures for handling these particular hazardous materials include the following:

a. Using a hood where the specific procedures will be carried out. All hoods are identified as areas of special hazard, and access should be restricted to personnel who are trained about the hazards and safe handling of the materials.

b. Decontamination procedures include extra precautions on the part of lab workers in maintaining good personal hygiene. No food, beverages, or tobacco products will be permitted in the restricted areas, and workers should wash after working at any hood.

c. Procedures for safe removal of contaminated waste should be consistent with the laboratory's hazardous waste policy and must meet the requirements of applicable regulations.

The following are recommendations for handling of specific classes of particularly hazardous substances. A list of such hazardous substances used in the laboratory is found in Appendix E.

Allergens (Examples: diazomethane, isocyanates, bichromates)

- A wide variety of substances can produce skin and lung hypersensitivity. Because of this variety and because of the varying response of individuals, suitable gloves and eye protection should be used to prevent hand and eye contact with allergens or substances of unknown allergenic activity.

Embryotoxins (Examples: organomercurials, lead compounds, formamide)

- Because the period of greatest susceptibility to embryotoxins is the first 8 to 12 weeks of pregnancy, which includes a period when a woman may not know she is pregnant, women of child-bearing potential should take care to avoid skin contact with all chemicals. All hoods or other essential engineering controls should be known to be operating at required efficiency before work with embryotoxins is started.

- Store these substances--properly labeled--in an adequately ventilated area in a proper container.

- Notify the Laboratory Manager, Safety Committee, and Division Safety Officer of all incidents of exposure or spills. Consult a qualified physician when appropriate.

Chemicals of Moderate and High Chronic or High Acute Toxicity (Examples: diisopropylfluorophosphate, hydrofluoric acid, hydrogen cyanide)

- Supplemental rules are to be followed, in addition to those mentioned above.

- The aim is to minimize exposure to these toxic substances by any route using all reasonable precautions.

- Use and store these substances only in areas of restricted access with special warning signs.

- Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 60 linear feet per minute) or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance. Trap released vapors to prevent their discharge with the hood exhaust, in case of major spills.

- Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate). Always wash hands and arms immediately after working with these materials.

- Make sure that at least two people are present at all times if a compound in use is highly toxic or of unknown toxicity.

- Store containers of these chemicals in a ventilated area in appropriately labeled, unbreakable, chemically resistant containers.

- Use chemical decontamination by chemical conversion whenever necessary. See Appendix A, Waste Disposal Policy, and the section for storage and disposal of contaminated waste.

- Clean the hood after each use.

- Remove any contaminated protective apparel and dispose of it properly.

- If using toxicologically significant quantities of such a substance on a regular basis (for example, three times a week), consult a qualified physician concerning desirability of regular medical surveillance.

- Make sure that the controlled area (or hood) is conspicuously marked with warning and/or restricted access signs and that all containers of these substances are appropriately labeled with identity and warning labels.

- Make sure that contingency plans, equipment, and materials to minimize exposures of people and property, in case of an accident, are available.

III. ENGINEERING CONTROL MEASURES

A. Hoods

Engineering controls start with the general ventilation system, which should have air intakes and exhausts located so as to avoid intake of contaminated air. This system should provide a source of air for breathing and for input to local ventilation devices. It should not be relied on for protection from toxic substances released into the laboratory. The system should ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day, and direct air flow into the laboratory from nonlaboratory areas and out to the exterior of the building. Thus, air pressure in the laboratories should always be negative with respect to the rest of the building. Also, air intakes for a laboratory building should be located in such a way that reduces the possibility that the input air will be contaminated by exhaust air.

The fume hood is the primary engineering control in the lab. A laboratory hood with adequate hood space should be provided as needed. Each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use. If this is not possible, work with substances of unknown toxicity should be avoided or other types of local ventilation devices should be provided.

Other local ventilation devices include ventilated storage cabinets and canopy hoods. These should be provided as needed. Each canopy hood should have a separate exhaust duct.

Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate.

Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure.

1. Use of a Hood

a. Use the hood for operations which might result in the release of toxic or hazardous chemical vapors or dust. A hood should be considered as a backup safety device to contain and exhaust toxic, offensive, or flammable materials. It is not a method for disposing of chemicals. Apparatus used in hoods should be fitted with condensers, traps, or scrubbers to contain and collect waste solvents or toxic vapors or dusts. Highly toxic or offensive vapors should always be scrubbed or adsorbed before the exit gases are released into the hood exhaust system.

b. A hood should be evaluated before use to ensure adequate face velocities, usually 60-150 lfm. As a general rule, use a hood or other local ventilation device when working with any volatile substance with a TLV of less than 50 ppm. There should be no excessive turbulence. Use some continuous monitoring device for adequate hood performance. It should be checked before a hood is used. Confirm the performance of a hood to be sure it is adequate before use. If the performance of the hood is inadequate for the operation or chemicals involved, do not use it.

c. Keep hoods closed, vertical sashes down, and horizontal sashes closed, except for adjustments. A small face opening of the hood improves its overall performance.

d. The airflow pattern and the performance of a hood depends on such factors as the placement of equipment in the hood, room drafts from open doors and windows, persons walking by, and the presence of the user in front of the hood.

e. Hoods are not intended primarily for storage of chemicals. Materials stored in them should be kept to a minimum. They should not block vents or alter airflow patterns. When possible, store chemicals in vented cabinets.

f. Solid objects and materials such as paper should not enter exhaust ducts.

g. Appropriate actions should be taken in case of ventilation failure or other unexpected occurrences such as fire or explosion in the hood.

h. Energy can be conserved by turning off the hood when not in use if it is confirmed there is adequate general laboratory ventilation and if toxic substances are not stored in the hood.

i. *ONLY USE CHEMICALS FOR WHICH THE VENTILATION SYSTEM IS APPROPRIATE. DO NOT EXCEED THE LIMITATIONS OF THE SYSTEM.*

j. Keep materials six inches or more back from front edge of the sash. Immediately clean up any major spills occurring inside the hood. Use only grounded electrical equipment. Do not block baffle or grille openings, generate large quantities of flammables within the hood, or permit temperature of the sash glass to exceed 160^0 F.

2. Hood Evaluation

   a. Ventilation should be evaluated when it is installed and on a regular basis, at least every three months.

   b. It should be reevaluated whenever there is a change in any aspect of the ventilation system. Thus, changes in the total volume of input air, changes in the locations of air-input ports, or the addition of other auxiliary local ventilation devices call for re-evaluation of all hoods in the laboratory.

   c. The measurement of airflow rates requires special instruments and personnel trained to use them. Pitot tubes are used for measuring duct velocities, and anemometers or velometers are used to measure airflow rates within rooms and at the faces of input or exhaust ports. The proper calibration and use of these instruments requires specialized training to ensure the accurate collection and evaluation of data.

B. Other Engineering Controls

1. Other engineering controls include special containers and storage equipment for substances with specific hazards.

2. Flammable and combustible liquids should be kept in safe containers designed for that purpose. Quantities greater than one liter should be stored in metal containers or an appropriate storage area. Portable safety cans have spring-loaded spout covers that can open to relieve internal pressure when subjected to a fire and will prevent leakage if tipped over. Some are equipped with a flame arrester in the spout that will prevent flame propagation into the can. Cans must be properly labeled to identify their contents.

3. Small quantities of flammable liquids should be stored in ventilated metal cabinets or in appropriate storage areas. Typical construction is a double-walled configuration of 18-gauge steel with riveted and spot-welded seams. The door is two inches above the floor, and the cabinet is liquid tight at this point. It is provided with vapor-venting provisions and can be equipped with a sprinkler system. (Do not store materials that react with water in sprinkler-equipped cabinets.)

4. Materials that are corrosive must be stored in cabinets designed to hold them. Special care must be taken to separate acids from bases by distance or barrier.

5. Special precautions must be followed when handling chemicals that are defined as reactive to prevent mixing with other chemicals, except under controlled conditions. Storage for reactive chemicals must be segregated. Personal protective equipment must be used and other precautions followed.

6. Safety showers shall be provided in areas where chemicals are handled for immediate first aid treatment of chemical splashes and for extinguishing clothing fires. Safety showers shall be tested at least every six months.

7. Eyewash fountains shall provide a soft stream or spray of aerated water for an extended period (15 minutes) and be inspected at least every three months.

8. Work areas should be kept clean and free from obstructions. Cleanup should be done at the end of an operation or at the end of each day.

9. Wastes should be deposited in appropriate receptacles.

10. Spills should be cleaned up immediately and disposed of properly.

11. Unlabeled containers and chemical wastes should be disposed of promptly by appropriate means.

12. Floors should be cleaned regularly.

13. Stairways and hallways should NOT be used as storage areas, even for a brief time.

14. Access to exits, emergency equipment, and utility controls MUST ALWAYS BE KEPT CLEAR.

15. Properly store equipment and chemicals.

16. Respirators for routine use should be inspected at least every six months by the laboratory supervisor or designated personnel.

17. Other safety equipment should be inspected at least every six months.

18. Informal inspections should be done continually.

C. Criteria for the Use of Control Measures

1. The use of any engineering control, protective equipment, or hygiene practice will be determined by the chemical(s) being used.

2. The four overriding principles of chemical hygiene are:

   a. Minimize all chemical exposure.

   b. Do not underestimate risk.

   c. Provide adequate ventilation.

   d. Observe Permissible Exposure Limits and Threshold Limit Values.

   These principles provide the general criteria for the use of control measures in the laboratory.

The nature of the hazard presented by the chemical will determine the type of protection. For example, a person handling a corrosive material is required to wear appropriate gloves, eye protection, and a lab coat or other protective clothing. If the material or process might result in toxic fumes or vapors, then ventilation is an important control.

In general, if the Permissible Exposure Limit/Threshold Limit Value of a substance is low or the substance has a high-vapor pressure, ventilation and/or respiratory protection should be used.

The severity of the hazard will determine the extent of the control to be used. If the material is slightly corrosive, goggles alone might be enough--but if it is very corrosive, a full-face shield would be in order. If the fumes are slight, working in a hood might be adequate, but if the fumes are likely to be heavy or extremely toxic, then a closed system or respirators might be necessary.

Information on the hazards that will determine the type and extent of control measures can be found in the manufacturer's Material Safety Data Sheets, as well as in information from the Occupational Safety and Health Administration and the American Conference of Governmental Industrial Hygienists.

IV. PROCUREMENT, DISTRIBUTION, AND STORAGE

A. Procurement

Personnel who requisition hazardous substances and those who approve the purchase orders must be aware of the potential hazards involved, determine where there are adequate facilities and trained personnel available to handle such substances, and ensure a safe disposal method.

Contact the manufacturer for a Material Safety Data Sheet and secure other appropriate information.

It may be preferable to order a substance in small-container lots to avoid the hazards associated with repackaging.

Personnel receiving a substance must be given the information about proper handling, storage, and disposal before it is received for permanent storage.

No container should be accepted without a label adequately identifying the contents. The label should list at least the following information:

- Identification of the contents of the container;
- Signal word and summary description of any hazards;
- Precautionary information -- what to do to minimize hazards and prevent an accident;
- First aid in case of an exposure;
- Spill and cleanup procedures;
- If appropriate, special instructions to physicians.

It is preferable to have all substances received in a central location.

Receiving room, storeroom, and stockroom personnel should be trained in the handling of hazardous substances and be familiar with the following information:

1. The use of proper material handling equipment, protective apparel, and safety equipment.
2. Emergency procedures, including the cleanup of spills and the disposal of broken containers.

3. The dangers of contacting chemicals by skin absorption, inhalation, or ingestion.

4. The meanings of the various DOT labels on shipping packages.

5. The proper methods of material handling and storage, especially the incompatibility of some common substances; the dangers associated with alphabetical storage; the sensitivity of some substances to heat, moisture, and light; and other storage hazards.

6. The special requirements of heat-sensitive materials, including those shipped refrigerated or packed in dry ice.

7. The problems associated with compressed gases.

8. The hazards associated with flammable liquids (especially the danger of their vapors catching fire some distance from the container) and explosives, toxic gases and vapors, and oxygen displacement.

9. Substances that react with water giving rise to hazardous conditions.

10. The federal and state regulation governing controlled substances such as radioactive materials, drugs, ethyl alcohol, explosives, and needles and syringes.

11. Chemicals that have offensive smells.

12. Packages that exhibit evidence that the inside container has broken and leaked its contents.

B. Stockrooms/Storerooms

Toxic substances should be segregated in a well-identified area with local exhaust ventilation. Toxic substances should be segregated from other substances and stored in a well-identified area that is cool, well-ventilated, and away from light, heat, acids, oxidizing agents, moisture, etc.

Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity. Chemicals should be dated when received and when initially opened.

Stockrooms/storerooms should not be used as preparation or repackaging areas.

Incompatible chemicals should not be stored together (see following table).

Classes of Incompatible Chemicals [1]	
A	**B**
Acids	Bases
Alkali and alkaline earth metals carbides hydrides hydroxides oxides peroxides	Water Acids Halogenated organic compounds *Oxidizing Agents* [2] Chromates, dichromates, CrO_3 Halogens Halogenating agents Hydrogen peroxide and peroxides Nitric Acid, nitrates Perchlorates and chlorates Permanganates Persulfates
Inorganic azides	Acids Heavy metals and their salts *Oxidizing Agents* [2]
Inorganic cyanides	Acids, strong bases
Inorganic nitrates	Acids Metals Nitrites Sulfur
Inorganic Nitrites	Acids *Oxidizing Agents* [2]
Inorganic sulfides	Acids
Organic compounds Organic acyl halides Organic anhydrides Organic halogen compounds Organic nitro compounds	*Oxidizing Agents* [2] Bases Organic hydroxy compounds Bases Organic hydroxy compounds Aluminum metal Strong bases
Powdered metals	Acids *Oxidizing Agents* [2]

Specific Chemical Incompatibilities [1]	
A	**B**
Acetylene and monosubstituted acetylene (R—C≡CH)	Halogens Group IB and IIB metals and their salts
Ammonia and NH_4OH	Halogens Halogenating agents Silver Mercury
Carbon, activated	*Oxidizing agents* [2]
Hydrogen peroxide	Metals and their salts
Nitric acid	Metals Sulfuric acid Sulfides Nitrites, other reducing agents Chromic acids and chromates Permanganates
Mercury and its amalgams	Ammonia and NH_4OH Nitric acid Acetylene Sodium azide
Oxalic acid	Silver Mercury
Phosphorus (yellow)	Oxygen *Oxidizing agents* [2] Strong bases
Phosphorus pentoxide	Water Halogenating agents
Sulfuric Acid	Metals Chlorates Perchlorates Permanganates Nitric Acid

[1] Chemicals in columns A and B should be kept separate.

[2] Oxidizing agents include the types of compounds listed in the entry for alkali and alkaline earth metals, etc.

C. Laboratory Storage

The amounts permitted in storage should be as small as practical. Decisions about amounts should be based on the level of competence of the workers, the level of safety features designed into the facility, the location of the laboratory, the nature of the chemical operations, and the accessibility of the stockroom. In some cases, local regulations or insurance requirements will also be a determining factor.

Every chemical in the laboratory should have a definite storage place and should be returned to that location after each use.

Bulk chemicals should not be stored on bench tops or in hoods.

Storage trays or secondary containers should be used to minimize the distribution of material should a container break or leak.

Ventilated cabinets located near hoods are desirable.

Flammable liquids should not be stored in laboratory refrigerators unless the unit is an approved, explosion-proof or laboratory-safe type.

All containers in a laboratory refrigerator must be properly labeled including identification of the contents, owner, date of acquisition or preparation, and nature of any potential hazards.

Avoid exposure to heat or direct sunlight.

D. Signs and Labels

Be certain all chemicals are correctly and clearly labeled.

Laboratory areas that have special or unusual hazards should be posted with warning signs. These hazards may be radiation, x-ray, laser operations, flammable materials, biological hazards, or other special situations.

Post prominent signs and labels such as:

- Emergency telephone numbers of emergency personnel/facilities in the event of fire, accident, flood, or hazardous chemical spill.

- Telephone numbers for supervisors and laboratory workers to be contacted in the event of an accident or emergency.
- Identity labels showing contents of containers (including waste receptacles) and associated hazards.
- Location signs for safety showers, eyewash stations, other safety and first aid equipment, and exits.
- Areas where food and beverages may be consumed and stored.

V. WASTE DISPOSAL

Proper disposal of waste or used substances is everyone's responsibility. Methods of disposal may vary from lab to lab depending on the waste chemicals involved. One principle must always be followed:

- **The disposal method must not harm people or the environment.**

The Crime Laboratory Division Commander with the Crime Laboratory Manager shall make sure the layout for each laboratory operation includes plans and training for waste disposal. Avoid hazards to the environment by following accepted waste-disposal procedures as per local regulations. Chemical reactions may require traps or scrubbing devices to prevent the escape of toxic substances.

Deposit chemical waste in correctly labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene and Safety Plan.

Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened. Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage.

If an experiment creates new disposal considerations, they should be discussed with the laboratory supervisor and, if necessary, the Chemical Hygiene and Safety Officer.

A. Disposal of Chemical Wastes

1. There are procedures for the collection and proper disposal of solid, liquid, and especially-hazardous wastes from the laboratories and proper disposal by the facility. Laboratory workers should be responsible for identifying hazards in handling, transporting, storing, and disposing of generated wastes.

2. Chemical and biohazardous wastes should be placed in properly-labeled containers and disposed of properly:

    a. Acids and bases shall be neutralized, diluted, and washed down the sink with excess running water.

b. Mercury will be disposed of in a specifically designated mercury waste container, which is then disposed of by a hazardous chemical waste disposal company.

c. Heavy metals (excluding mercury) will be disposed of in a specifically designated heavy-metals (excluding mercury) waste container, which is then disposed of by a hazardous chemical waste disposal company.

d. Ethyl ether and other chemicals which form peroxides or are shock sensitive shall be stored in approved containers in an approved location and disposed of by appropriate qualified disposal personnel. Open containers of ethyl ether older than six-months, unopened containers of ethyl ether older than one-year, or waste quantities greater than 200 ml shall be disposed of in this manner.

e. Thoroughly dried blood may be disposed of carefully in an appropriate receptacle. Non-dry blood must be either thoroughly dried and disposed of as above, or stored in an appropriate container to be incinerated.

3. Incompatible materials should be segregated.

4. Laboratory procedures should be used to produce less hazardous substances.

5. Check with the supervisor, safety coordinator, or Chemical Hygiene and Safety Officer about local, state, and federal regulations regarding waste disposal.

B. Considerations for Disposal to the Sewer System

1. Dispose of water-soluble substances only in the laboratory sink. Dilute flammable solvents sufficiently to eliminate the fire hazard.

2. Strong acids and bases should be diluted to the pH 6-9 range before being poured into the sewer system. Acids and alkalis should not exceed a rate equivalent to 50 ml of concentrated substance per minute.

3. Highly toxic, malodorous, or lachrymatory chemicals should not be put down the drain. Interconnected drains could create a vapor release from another drain. Substances poured down different drains could come in contact and create problems.

4. Where permissible, small amounts of some heavy-metal compounds may be disposed of in the sink, but larger amounts may pose a hazard for the sewer system or water supply. Therefore, dispose of heavy-metal wastes in appropriate containers which will then be disposed of by a hazardous chemical waste disposal company.

5. Check with the supervisor, safety coordinator, or Chemical Hygiene and Safety Officer about local, state, and federal regulations about waste disposal.

   See Appendix A for waste disposal regulations and restrictions.

VI. EXPOSURE DETERMINATION

It is the Laboratory Manager's responsibility to determine when exposure monitoring is necessary or appropriate, and the Laboratory worker's responsibility to report concerns to the Chemical Hygiene and Safety Officer and the Laboratory Manager.

Regular, routine monitoring of the airborne concentrations of a variety of different toxic materials is generally not required, as long as care is taken to ensure the following:

1. The ventilation system (including the hood) is performing and is being used properly.

2. The laboratory workers are using proper protective equipment and clothing.

3. The laboratory workers are following good hygiene and laboratory safety practices.

However, there are situations where monitoring of individual compounds is appropriate or required:

1. In testing and redesigning hoods and other ventilation devices in the laboratory, air-sampling procedures may be helpful in the evaluation of the new ventilation situation.

2. If a specific substance is highly toxic and regularly used in the laboratory, instrumental monitoring of that substance may be appropriate. This is especially true if a relatively large amount of the material is being stored or used in the laboratory.

3. Measurement of employees' exposure to any substance regulated by a standard which requires monitoring is necessary if there is reason to believe that exposure levels for that substance routinely exceed the action level for the substance (or, in the absence of an action level, the Permissible Exposure Limit [PEL]).

If this monitoring indicates exposure over the action level or PEL, then the employer must immediately comply with the monitoring provisions of the relevant standard.

The agency must notify employees of the results of any monitoring procedures. This notification will be in writing, within 15 days of the receipt of the monitoring.

VII. MEDICAL CONSULTATIONS AND EXAMINATIONS

The Chemical Hygiene and Safety Plan provides the opportunity, under certain circumstances, for all employees who work with hazardous chemicals to receive medical attention, including any follow-up examinations which the examining doctor feels is necessary.

It is laboratory policy to promptly investigate all complaints to determine risk of employee overexposure to the toxic substances in their work place.

There should be a medical consultation whenever there is reason to believe an employee has been exposed to a hazardous chemical.

All medical examinations and consultations must be performed by (or under the direct supervision of) a licensed physician at no cost to the employee, without loss of pay and at a reasonable time and place. All medical documentation will be sent to the Personnel Section to be retained 30 years after an employee's termination.

Some examples of circumstances that would indicate the possibility of exposure are:

- The employee had direct skin or eye contact with a chemical substance;
- Odor was noticed, especially if the employee was working with any chemical which has a PEL or TLV below the odor threshold;
- The employee is experiencing health hazard symptoms such as headache, rash, nausea, coughing, tearing, irritation or redness of eyes, irritation of nose or throat, dizziness, loss of motor dexterity or judgement which resemble drunkenness, etc;
- Some or all of the symptoms disappear when the employee is taken away from the chemical area and into fresh air;
- Symptoms previously complained about reappear soon after the employee starts working with chemicals again;
- Complaints are received from more than one person in the same work area;

- When exposure monitoring reveals an exposure level routinely above the action level (or PEL in the absence of an action level);

- Whenever there is a spill, leak, or other release resulting in the likelihood of a hazardous exposure.

The following information must be provided to the physician:

- The identity of the hazardous chemical to which the employee may have been exposed;

- A description of the conditions under which the exposure occurred, including quantitative exposure data if available; and

- A description of the signs and symptoms of exposure that the employee is experiencing, if any.

The Laboratory Manager must obtain a written report from the physician which includes:

- The results of the medical examination and any associated tests;

- Any recommendation for further medical follow-up;

- Any medical condition which may be revealed which may place the employee at increased risk as a result of a hazardous chemical found in the work place;

- A statement that the employee has been informed by the physician of the results of the examination and any medical condition that may require further examination or treatment;

- A Labor and Industries report is necessary if the condition is due to or suspected of being job related.

The physician's statement should not include findings unrelated to occupational exposure. A copy of the physician's report should be sent to the Division Safety Officer.

The Laboratory Manager may find it appropriate to conduct an "exposure evaluation" when there is a complaint of a possible hazardous exposure. The basic steps of this evaluation are:

1. Interviewing the person initiating the complaint and the victim if it is not the same person.

2. Listing the essential information about the circumstances of the complaint, including:

   a. Chemical of suspicion

   b. Other chemicals in use by the victim

   c. Other chemicals being used by others in the immediate area

   d. Other chemicals stored in that area

   e. Signs and symptoms being experienced

   f. Were control measures, such as fume hoods and personal protective equipment, used and were these control measures functioning properly?

   g. Are any air sampling or monitoring devices in place or available?

3. Air sampling of the area for suspect chemicals

4. Determining how the signs and symptoms being experienced compare with the information on the Material Safety Data Sheets for the chemicals involved.

5. Deciding whether to send the employee for medical evaluation.

6. Review of the present control measures and safety procedures.

VIII. INFORMATION AND TRAINING

Information and training is a key part of this Chemical Hygiene and Safety Plan. The training and education program must be a regular and ongoing activity. Information should be updated continuously and refresher training in all areas should be conducted regularly and documented.

A. Information Requirements

The employees of the laboratory must have the information to ensure that they know and understand the hazards of the chemicals in their work area.

This information must be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present, and before assignments involving new exposure situations.

Employees must be informed of:

- The location, availability, and contents of this written Chemical Hygiene and Safety Plan;
- The location, availability, and contents of the Occupational Exposures to Hazardous Chemicals in Laboratories OSHA Standard (See Appendix G);
- The location and availability of standard reference material on the Permissible Exposure Limits, signs and symptoms associated with exposures to hazardous chemicals used in the laboratory, hazards, safe handling, storage, and disposal of the hazardous chemicals in the laboratory. This reference material includes, but is not limited to, the Material Safety Data Sheets from the manufacturers.

B. Training Requirements

1. Methods and observations that may be used to detect the presence or release of a hazardous chemical, such as:
   a. Monitoring conducted by the employer
   b. Continuous monitoring devices
   c. Appearance or odor of hazardous chemicals when released

2. Training about the physical and health hazards of chemicals in the work area and protection from those hazards.

3. Appropriate laboratory personnel should be trained in the proper use of emergency equipment and procedures.

4. All personnel, including Administrative Support personnel, should know about the hazards of the materials moving into and through their work areas, proper use of handling equipment, protective apparel, and relevant regulations.

5. Location of emergency evacuation routes, exits, showers, eye washes, fire extinguishers, first aid kit, fire blanket, alarms, and other safety devices.

6. The following Safety Orientation Checklist must be taught in Safety Training. The Laboratory Manager is responsible to see that this training is received by all laboratory employees.

   There will be written documentation that this training and information has been received and understood by the Laboratory worker. The original documentation will be on file in the laboratory and a copy will be filed with the Division Safety Officer.

C. Safety Orientation Checklist

   1. Location of Safety Equipment and Materials

      a. Fire extinguishers (different types and proper use)

      b. First aid stations

      c. Other first aid supplies such as blankets, disposable clothing, earplugs, and respirators and respirator program.

      d. MSDS files

      e. Hazardous chemical references

      f. Spill kits and Spill control plan

      g. Eye washes

      h. Showers

i. Fire blanket

j. Fire alarms

k. Safety Manual/Chemical Hygiene and Safety Plan

l. Asset Management Manual Emergency Handbook

2. Evacuation Routes, Emergency Exit Plans

3. Types of Fire Alarms

   a. Smoke detector

   b. Building intercom

   c. Horn and flashing lights

4. Basic Safety Rule Review

   a. No food or drink on lab bench. Use food refrigerator for food storage.

   b. ***When appropriate, use eye protection (goggles or shields) when handling chemicals, unknown substances, or liquid body fluids.***

   c. ***Wear protective gloves when working with body fluids or clothing with biological stains when appropriate.***

   d. ***Wear lab coat in lab, remove it when you leave the lab.***

   e. ***Don't put your hands blindly into packaging or into evidence clothing pockets.***

   f. Use solvents and other volatiles in or near hoods.

   g. Clean up floor spills immediately or identify and protect the spill area until clean-up occurs.

   h. Limit use of known carcinogens such as benzene and chloroform.

   i. Gas tanks

      (1) When moving tanks cap them securely and use proper carts.

(2) Always strap tanks securely at their destination whether they are being stored or used.

j. Keep fire escape doors clear; keep aisles clear.

k. Dispose properly of scalpel blades, syringes, and broken glass.

l. Chemical storage room hazards--isolation and proper storage of incompatible chemicals.

m. Accidents

(1) Always help someone who may be injured. If the injury is not minor, FIRST call for assistance (e.g., 911 and/or a first aid/CPR trained individual), then provide the assistance which you are able to render.

(2) Promptly report all accidents and/or injuries to your supervisor.

n. No smoking in the building or in state vehicles.

o. Do not overload bookshelves.

p. Use step stools to reach high places.

q. Know the location of the Safety Bulletin Board.

r. Hood use.

5. Do not enter Firearms Section test firing area while test firing is in progress.

6. Safety Committee

a. Lab Committee - Members

b. System-wide Committee

c. Chemical Hygiene and Safety Officer

ITALICS, BOLD - emphasize biohazards

WASTE DISPOSAL PLAN

APPENDIX A

WASHINGTON STATE PATROL

CRIME LABORATORY

CHEMICAL HYGIENE AND SAFETY PLAN

SPILL CONTROL PLAN

APPENDIX B

WASHINGTON STATE PATROL

CRIME LABORATORY

CHEMICAL HYGIENE AND SAFETY PLAN

RESPIRATOR PROGRAM

APPENDIX C

WASHINGTON STATE PATROL

CRIME LABORATORY

CHEMICAL HYGIENE AND SAFETY PLAN

EMERGENCY EVACUATION PLAN

APPENDIX D

WASHINGTON STATE PATROL

WSP

CRIME LABORATORY

CHEMICAL HYGIENE AND SAFETY PLAN

PARTICULARLY HAZARDOUS SUBSTANCES

EXAMPLES OF INCOMPATIBLE CHEMICALS

CHEMICALS LISTED IN ANNUAL REPORT ON CARCINOGENS

APPENDIX E

WASHINGTON STATE PATROL

WSP

CRIME LABORATORY

CHEMICAL HYGIENE AND SAFETY PLAN

EXAMPLES OF INCOMPATIBLE CHEMICALS

CHEMICAL	KEEP OUT OF CONTACT WITH:
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permangantes
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkaline	Water, carbon tetrachloride or other chlorinated metals, hydrocarbon, carbon dioxide, the halogens such as powdered aluminum or magnesium, sodium, potassium
Ammonia, anhydrous	Mercury (in manometer, for instance), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, metals, powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Bromine	Same as for chlorine
Carbon, activated	Calcium hypoclorite, all oxidizing agents
Chlorates	Ammonium salts, acids, metals, powders, sulfur, finely divided organic or cumbustible 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, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene	Acids, organic or inorganic hydroperoxide
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, the halogens
Fluorine	Isolate from everything
Hydrocarbons (butane, propane, benzene, gasoline, turpentine, etc.)	Fluroine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali

EXAMPLES OF INCOMPATIBLE CHEMICALS

CHEMICAL	KEEP OUT OF CONTACT WITH:
Hydrofluoric acid, anhydrous	Ammonia, aqueous or anhydrous
Hydrogen	Fuming nitric acid, oxidizing gases
Iodine	Acetylene, ammonic (aqueous or anhydrous), hydrogen
Mercury	Acetylene, ammonia
Nitric Acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Oxalic acid	Silver, mercury
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds

CHEMICALS LISTED IN ANNUAL REPORT ON CARCINOGENS

Substance name	CAS No.
2-Acetylaminofluorene	53-96-3
Acrylonitrile	107-13-1
Adriamycin	23214-92-8
Aflatoxins	1402-68-2
1-Amino-2-methylanthraquinone	82-28-0
2-Aminoanthraquinone	117-79-3
4-Aminobiphenyl	92-67-1
Amitrole	61-82-5
0-Anisidine	90-04-0
and o-Anisidine Hydrochloride	134-29-2
Aramite	140-57-8
Arsenic	7440-38-2
and certain arsenic compounds	1327-53-3
Asbestos	1332-21-4
Azathioprine	446-86-6
Benzene	71-43-2
Benzidine	92-87-5
Benzotrichloride	98-07-7
Beryllium and certain beryllium compounds	7440-41-7
N,N-bis (2-chloroethyl)-2-naphthylamine (chlornaphazine)	494-03-1
Bis (chloromethyl) ether and technical grade chloromethyl methyl ether	542-88-1
Bischloroethyl nitro-sourea	154-93-8
1,4-Butanediol dimethy-sulfonate (myleran)	55-98-1
Cadmium and certain cadmium compounds	7440-43-9
Carbon tetrachloride	56-23-5
Chlorambusil	305-03-3
4-Chloro-o-phenylene-diamine	95-83-0
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)	13010-47-4
Chloroform	67-66-3
Chromium and certain chromium compounds	7440-47-3
Coke oven emissions	NA
p-Cresidine	120-71-8
Cupferron	135-20-6
Cycasin	14901-08-7
Cyclophosphamide	50-18-0
Dacarbazine	4342-03-4
DDT	50-29-3
Di (2-ethylhexyl) phthalate	117-81-7
2,4-Diaminoanisole sulfate	391-41-7
2,4-Diaminotoluene	95-80-7
1,2-Dibromi-3-chloropropane	96-12-8
1,2-Dibromoethane (EDB)	106-93-4
3,3'-Dichlorobenzidine	91-94-1
1,2-Dichloroethane	107-06-2
Diepoxybutane	1464-53-5
Diethyl sulfate	64-67-5
Diethylstilbestrol (DES)	56-53-1
3,3'-Dimethoxybenzidine	119-90-4
Dimethyl sulfate	77-78-1
4-Dimethylaminoazobenzene	60-11-7
3,3'-Dimethylbenzidine	119-93-7
Dimethylcarbamoyl chloride	79-44-7
1,1-Dimethylhydrazine	57-14-7
1,4-Dioxane	123-91-1
Direct Black 38	1937-37-7
Direct Blue 6	2602-46-2
Epichlorohydrin	106-89-8
Estrogens-conjugated: a) Estradiol benzoate b) Estradiol monopalmitate	50-50-0
Estrogens-not conjugated: a) Estradiol 17 beta	50-28-2
Estrogens-not conjugated: b) Estrone (metabolite of Estradiol 17 beta)	53-16-7
Estrogens-not conjugated: c) Ethinylestradiol	57-63-6
Estrogens-not conjugated: d) Mestranol	72-33-3
Ethylene thiourea	96-45-7
Ethylene oxide	75-21-8
Formaldehyde	50-00-0
Hematite underground mining	NA
Hexachlorobenzene	118-74-1
Hexamethylphosphoramide	680-31-9
Hydrazine &	302-01-2
Hydrazine Sulfate	10043-93-2
Hydrazobenzene	122-66-7
Iron dextran complex	9004-66-4
Isopropyl alcohol manufacture (strong-acid process)	NA
Kepone (Chlordecone)	143-50-0
Lead acetate	301-04-2
Lead phosphate	7446-27-7
Lindane (y-hexachlorocyclohexane)	58-89-9
Lindane (b-Hexachlorocyclohexane)	319-85-7

CHEMICALS LISTED IN ANNUAL REPORT ON CARCINOGENS

Substance name	CAS No.
Lindane (Hexachlorocyclohexane)	608-73-1
Manufacture of auramine	NA
Melphalan	148-82-3
Methoxsalen with ultra-violet A therapy (PUVA)	NA
Methyl iodide	74-88-4
2-Methylaziridine (propyleneimine)	75-55-8
4,4'-Methylenebis (N,N-dimethyl) benzemine (Michler's base)	101-61-1
4,4'-Methylenebis (2-chloroaniline) (MBOCA)	101-14-4
4,4'-Methylenedianiline and its dihydrochloride	101-77-9
Metronidazole	443-48-1
Michler's ketone	90-94-8
Mirex	2385-85-5
Mustard gas	505-60-2
2-Naphthylamine	91-59-8
Nickel and certain nickel compounds	7440-02-0
Nitrilotriacetic acid	139-13-9
Nitrofen	1836-75-5
Nitrogen mustard	55-86-7
5-Nitro-o-anisidine	99-59-2
2-Nitropropane	79-46-9
N-Nitroso-N-ethylurea	759-73-9
N-Nitroso-N-methylurea	684-93-5
N-Nitrosodi-n-butylamine	924-16-3
N-Nitrosodi-n-propylamine	621-64-7
N-Nitrosodiethanolamine	1116-54-7
N-Nitrosodiethylamine	55-18-5
N-Nitrosodimethylamine	62-75-9
p-Nitrosodiphenylamine	156-10-5
N-Nitrosomethylvinylamine	4549-40-0
N-Nitrosomorpholine	59-89-2
N-Nitrosonornicotine	16543-55-8
N-Nitrosopiperidine	100-75-4
N-Nitrosopyrrolidine	930-55-2
N-Nitrososarcosine	13256-22-9
Norethisterone	68-22-4
Oxymetholone	434-07-1
PAHs:	
a) Benz (a) anthracene	56-55-3
b) Benzo (b) fluoranthene	205-99-2
c) Benzo (a) pyrene	50-32-2
d) Dibenz (a,h) acridine	226-36-8
e) Dibenz (a,j) acridine	226-36-8
f) Dibenz (a,h) anthracene	53-70-3
g) 7H-Dibenzo (c,g) carbazole	194-59-2
h) Dibenzo (a,h) pyrene	189-64-0
i) Dibenzo (a,i) pyrene	189-55-9
j) Indeno (1,2,3-cd) pyrene	193-39-5
Phenacetin and analgesic mixtures containing phenacetin	62-44-2
Phenazopyridine hydrochloride	136-40-3
Phenytoin and sodium salt of phenytoin	57-41-0
Polybrominated biphenyls	36355-01-8
Polychlorinated biphenyls	1336-36-3
Procarbazine	671-16-9
Procarbazine Hydrochloride	366-70-1
Progesterone	57-83-0
1,3-Propane sultone	1120-71-4
beta-Propiolactone	57-57-8
Propylthiouracil	51-52-5
Reserpine	50-55-5
Rubber industry (certain occupations)	NA
Saccharin	81-07-2
Safrole	394-59-7
Selenium sulfide	7446-34-6
Soots, tars, and mineral oils	8007-45-2
Streptozotocin	1883-66-4
Sulfallate	95-06-7
2,3,7,8-Tetrachlorodi-benzo-p-dioxin (TCDD)	1746-01-6
Thioacetamide	62-55-5
Thiourea	62-55-5
Thorium dioxide	1314-20-1
Toluene diisocynate	584-84-9
o-Toluidine	95-53-4
o-Toluidine Hydrochloride	636-21-5
Toxaphene	8001-35-2
2,4,6-Trichlorophenol	88-06-2
Tris (2,3-dibromopropyl) phosphate	126-72-7
Tris (1-aziridinyl) phosphine sulfide	52-24-4
Urethane	51-79-6
Vinyl chloride	75-01-4

HAZARD DATA FOR COMMON COMPRESSED GASES

APPENDIX F

WASHINGTON STATE PATROL

WSP

CRIME LABORATORY

CHEMICAL HYGIENE AND SAFETY PLAN

HAZARD DATA FOR COMMON COMPRESSED GASES

GAS	THRESHOLD LIMIT VALUES (ppm)	FLAMMABILITY LIMITS IN AIR, % BY VOLUME	MAJOR HAZARDS
Acetylene	Asphyxiant	2.4-81.0	Flammable; asphyxiant
Ammonia	25	15-28	Toxic
Argon	Asphyxiant	None	Asphyxiant
Boron trifluoride	1	None	Toxic; causes burns
1,3-Butadiene	1,000	2-11.5	Flammable; skin irritant
Carbon dioxide	5,000	None	Asphyxiant
Carbon monoxide	35	12.5-74.0	Flammable; toxic
Chlorine	1	None	Toxic; severe irritant; causes burns; corrosive
Ethylene	Asphyxiant	3.1-32.0	Flammable; asphyxiant
Ethylene oxide	1	3.0-100.0	Flammable; toxic; can cause burns when trapped by clothing or shoes
Helium	Asphyxiant	None	Asphyxiant
Hydrogen	Asphyxiant	4.0-75.0	Flammable; asphyxiant
Hydrogen bromide	3	None	Toxic; causes burns; corrosive
Hydrogen chloride	5	None	Toxic; causes burns; corrosive
Hydrogen fluoride	3	None	Toxic; causes severe, slow healing burns; corrosive

HAZARD DATA FOR COMMON COMPRESSED GASES

GAS	THRESHOLD LIMIT VALUES (ppm)	FLAMMABILITY LIMITS IN AIR, % BY VOLUME	MAJOR HAZARDS
Hydrogen sulfide	10	4.3-45.0	Toxic; flammable; irritant
Methane	Asphyxiant	5.3-14.0	Flammable; asphyxiant
Methyl bromide	5	13.5-14.5	Toxic; causes burns
Methyl chloride	50	10.7-17.4	Toxic; flammable
Methyl mercaptain	0.5	Unknown	Toxic; flammable
Nitrogen	Asphyxiant	None	Asphyxiant
Nitrogen dioxide	3	None	Toxic; corrosive
Oxygen	Non-toxic	None	Highly reactive
Phosgene	0.1	None	Toxic
Propane	Asphyxiant	2.2.-9.5	Flammable; asphyxiant
Sulfur dioxide	2	None	Toxic; causes burns
Vinyl Chloride	5	4.0-22.0	Flammable; causes burns

Source: Manufacturing Chemists Association, Guide for Safety in the Chemical Laboratory (New York, Van Nostrand Reinhold Company, 1972). Copyright 1972 by Manufacturing Chemists Association; reprinted by permission of the publisher.

CHEMICAL HYGIENE STANDARD

NATIONAL RESEARCH COUNCIL RECOMMENDATIONS

REFERENCES

APPENDIX G

WASHINGTON STATE PATROL

CRIME LABORATORY

CHEMICAL HYGIENE AND SAFETY PLAN

APPENDIX G - CHEMICAL HYGIENE STANDARD

INTRODUCTION

The Occupational Exposures to Hazardous Chemicals in Laboratories Standard establishes a wide range of requirements for laboratories to ensure that occupational exposure to hazardous chemicals in the laboratory environment is reduced or eliminated as far as possible.

In the preamble, OSHA summarizes the benefits of the standard:

"The new standard differs from many OSHA health standards in that it does not establish new exposure limits, but sets other performance provisions designed to protect laboratory workers from potential hazards in their work environment. By permitting a greater degree of flexibility to laboratories in developing and implementing employee safety and health programs, OSHA expects benefits to result from increased worker awareness of potential risks, improved work practices, appropriate use of existing personal protective equipment and greater use of engineering controls. Given the flexibility to design and implement measures to reduce employee exposure to hazardous substances, employers also will reap rewards in terms of lower insurance premiums, lower property damage costs, lower turnover costs, less absenteeism and, in general increased productivity. Finally, the potential decrease in acute and chronic health problems will result in overall benefits to society through the associated reduction in medical and productivity costs.

"A substantial amount of evidence in this record indicates that laboratory workers are at risk to serious and even life threatening occupational hazards. Several companies with good work practice programs, however, indicated that these hazards can be overcome through sound safety practices, and submitted evidence of the magnitude of the benefits to be attained from this standard."

This brief quote from the preamble of the standard summarizes the basic goals and approach of this standard. It is primarily a performance standard, giving wide latitude to individual laboratories in how to attain the desired results.

The text of the standard, including the appendices, is incorporated for reference purposes into this Chemical Hygiene and Safety Plan.

29CFR 1910.1450

Occupational exposure to hazardous chemicals in laboratories.

This section becomes effective May 1, 1990.

APPENDIX G - CHEMICAL HYGIENE STANDARD

(a) **Scope and application**

(1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(a)(2) Where this section applies, it shall supersede for laboratories the requirements of all other OSHA health standards in 29 CFR part 1910 subpart Z, except as follows:

(a)(2)(i) For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

(a)(2)(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(a)(2)(iii) Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.

(a)(3) This section shall not apply to:

(a)(3)(i) Uses of hazardous chemicals which do not meet the definition of laboratory use and in such cases the employer shall comply with the relevant standard in 29 CFR part 1910 subpart Z even if such use occurs in a laboratory.

(a)(3)(ii) Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

(a)(3)(ii)(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 supplied by the manufacturer of the test strip: and

(a)(3)(ii)(B) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

(b) Definitions

"Action level" means a concentration designated in 29 CFR part 1910 for a specific substance calculated as an eight (8)-hour time-weighted average which initiates certain required activities such as exposure monitoring and medical surveillance.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Carcinogen" (see "select carcinogen")

"Chemical Hygiene Officer" means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene and Safety Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

"Chemical Hygiene and Safety Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that

(i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular work place and

(ii) meets the requirements of paragraph (e) of this section.

"Combustible liquid" means any liquid having a flashpoint at or above 100 F (37.8 C), but below 200 F (93.3 C), except any mixture having components with flashpoints of 200 F (93.3 C) or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Compressed gas" means:

(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 F (21.1 C): or

(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 F (54.4 C) regardless of the pressure at 70 F (21.1 C): or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 F (37.8 C) as determined by ASTM D-323-72.

"Designated area" means an area which may be used for work with "select carcinogens," reproductive toxins, or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory, or a device such as a laboratory hood.

"Emergency" means any occurrence such as, but not limited to, equipment failure, rupture of containers, or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the work place.

"Employee" means an individual employed in a laboratory work place who may be exposed to hazardous chemicals in the course of his or her assignments.

"Explosive" means a chemical that causes a sudden, almost instantaneous, release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

"Flammable" means a chemical that falls into one of the following categories:

(i) "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening or a flashback (a flame extending back to the valve) at any degree of valve opening.

(ii) "Gas flammable" means:

(ii)(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or

(ii)(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume regardless of the lower limit.

(iii) "Liquid, flammable" means any liquid having a flashpoint below 100 F (37.8 C) except any mixture having components with flashpoints of 100 F (37.8 C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(iv) "Solid, flammable" means a solid other than a blasting agent or explosive as defined in 1910.109(a) that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical

shall be considered to be flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(i) Tagliabue Closed Tester--see American National Standard Method of Test for Flash Point by Tag Closed Tester, Z-11.24-1979 (ASTM D 56-79)-for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 F (37.8 C) that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester--see American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7-1979 (ASTM D 93-79)-for liquids with a viscosity equal to or greater than 45 SUS at 100 F (37.8 C) or that contain suspended solids or that have a tendency to form a surface film under test; or

(iii) Setaflash Closed Tester--see American National Standard Method of Test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78).

Organic peroxides which undergo autoaccelerating thermal decomposition are excluded from any of the flashpoint determination methods specified above.

"Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes or mucous membranes.

Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

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

"Laboratory scale" means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.

"Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

"Laboratory-type hood" means a device, located in a laboratory, enclosed on five sides with a moveable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms. Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

"Laboratory use of hazardous chemicals" means handling or use of such chemicals in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a "laboratory scale;"

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

"Medical consultation" means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

"Organic peroxide" means an organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

"Oxidizer" means a chemical other than a blasting agent or explosive, as defined in 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

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

"Protective laboratory practices and equipment" means those laboratory procedures, practices, and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective in minimizing the potential for employee exposure to hazardous chemicals.

"Reproductive toxins" means chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

"Select carcinogen" means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or

(ii) It is listed under the category "known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or

(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC)(latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(iv)(A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m^X3;

(iv)(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(iv)(C) After oral dosages of less than 50 mg/kg of body weight per day.

"Unstable (reactive)" means a chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure, or temperature.

"Water-reactive" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

(c) Permissible exposure limits.

For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910 subpart Z.

(d) Employee exposure determination.

(d)(1) Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level the PEL).

(d)(2) Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level the PEL) the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

(d)(3) Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.

(d)(4) Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing, either individually or by posting results in an appropriate location that is accessible to employees.

(e) Chemical hygiene plan.

General (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene and Safety Plan).

(e)(1) Where hazardous chemicals as defined by this standard are used in the work place, the employer shall develop and carry out the provisions of a written Chemical Hygiene and Safety Plan which is:

(e)(1)(i) Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory; and

(e)(1)(ii) Capable of keeping exposures below the limits specified in paragraph (c) of this section.

(e)(2) The Chemical Hygiene and Safety Plan shall be readily available to employees and employee representatives and upon request to the Assistant Secretary.

(e)(3) The Chemical Hygiene and Safety Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:

(e)(3)(i) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

(e)(3)(ii) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment, and hygiene practices. Particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

(e)(3)(iii) A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

(e)(3)(iv) Provisions for employee information and training as prescribed in paragraph (f) of this section;

(e)(3)(v) The circumstances under which a particular laboratory operation, procedure, or activity shall require prior approval from the employer or the employer's designee before implementation;

(e)(3)(vi) Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

(e)(3)(vii) Designation of personnel responsible for implementation of the Chemical Hygiene and Safety Plan including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee; and

(e)(3)(viii) Provisions for additional employee protection for work with particularly hazardous substances. These include select carcinogens, reproductive toxins, and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

(e)(3)(viii)(A) Establishment of a designated area;

(e)(3)(viii)(B) Use of containment devices such as fume hoods or glove boxes;

(e)(3)(viii)(C) Procedures for safe removal of contaminated waste; and

(e)(3)(viii)(D) Decontamination procedures.

(e)(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene and Safety Plan at least annually and update it as necessary.

(f) Employee information and training.

(f)(1) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

(f)(2) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

(f)(3) Information. Employees shall be informed of:

(f)(3)(i) The contents of this standard and its appendices which shall be made available to employees;

(f)(3)(ii) The location and availability of the employer's Chemical Hygiene and Safety Plan;

(f)(3)(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;

(f)(3)(iv) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

(f)(3)(v) The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.

(f)(4) Training

(f)(4)(i) Employee training shall include:

(f)(4)(i)(A) Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance, or odor of hazardous chemicals when being released etc.);

(f)(4)(i)(B) The physical and health hazards of chemicals in the work area; and

(f)(4)(i)(C) The measures employees can take to protect themselves from these hazards including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

(f)(4)(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene and Safety Plan.

(g) Medical consultation and medical examinations.

(g)(1) The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

(g)(1)(i) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination;

(g)(1)(ii) Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard;

(g)(1)(iii) 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, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

(g)(2) All medical examinations and 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.

(g)(3) Information provided to the physician. The employer shall provide the following information to the physician:

(g)(3)(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;

(g)(3)(ii) A description of the conditions under which the exposure occurred, including quantitative exposure date if available; and

(g)(3)(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.

(g)(4) Physician's written opinion.

(g)(4)(i) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

(g)(4)(i)(A) Any recommendation for further medical follow-up;

(g)(4)(i)(B) The results of the medical examination and any associated tests;

(g)(4)(i)(C) Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the work place; and

(g)(4)(i)(D) A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

(g)(4)(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

(h) Hazard identification.

(h)(1) With respect to labels and material safety data sheets:

(h)(1)(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced;

(h)(1)(ii) Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals and ensure that they are readily accessible to laboratory employees.

(h)(2) The following provisions shall apply to chemical substances developed in the laboratory:

(h)(2)(i) If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.

(h)(2)(ii) If the chemical produced is a byproduct whose composition is not known, the employer shall assume that all substance is hazardous and shall implement paragraph (e) of this section.

(h)(2)(iii) If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of material safety data sheets and labeling.

(i) Use of respirators.

Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide at no cost to the employee the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

(j) Record keeping.

(j)(1) The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations, including tests or written opinions, required by this standard.

(j)(2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

(k) Dates.

(k)(1) Effective date. This section shall become effective May 1, 1990.

(k)(2) Start-up dates.

(k)(2)(i) Employers shall have developed and implemented a written Chemical Hygiene and Safety Plan no later than January 31, 1991.

(k)(2)(ii) Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene and Safety Plan.

(l) Appendices. The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

APPENDIX G - NATIONAL RESEARCH COUNCIL RECOMMENDATIONS

29 CFR 1910 1450A Appendix A to 1910 1450

National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)

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FOREWORD

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene and Safety Plan, the following non-mandatory recommendations are provided. They were extracted from Prudent Practices for Handling Hazardous Chemicals in Laboratories (referred to below as Prudent Practices), which was published in 1981 by the National Research Council and is available from the National Academy Press, 2101 Constitution Avenue NW, Washington DC 20418.

Prudent Practices is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This Appendix merely presents pertinent recommendations from Prudent Practices organized into a form convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene and Safety Plan. Users of this appendix should consult Prudent Practices for a more extended presentation and justification for each recommendation.

Prudent Practices deals with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical hygiene" being substituted for

the word "safety." However, since conditions producing or threatening physical injury often post toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F.

The recommendations from Prudent Practices have been paraphrased, combined, or otherwise reorganized, and headings have been added. However, their sense has not been changed.

CORRESPONDING SECTIONS OF THE STANDARD AND THIS APPENDIX

The following table is given for the convenience of those who are developing a Chemical Hygiene and Safety Plan which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph	Topic in Laboratory Standard	Relevant Appendix Section
(e)(3)(i)	Standard Operating Procedures for handling toxic chemicals	C,D,E
(e)(3)(ii)	Criteria to be used for implementation of measures to reduce exposures	D
(e)(3)(iii)	Fume Hood Performance	C4b
(e)(3)(iv)	Employee information and training (including emergency procedures)	D10,D9
(e)(3)(v)	Requirements for prior approval of laboratory Activities	E2b,E4b
(e)(3)(vi)	Medical Consultation and medical examinations	D5,E4f
(e)(3)(vii)	Chemical Hygiene Responsibilities	B
(e)(3)(viii)	Special Precautions for work with particularly hazardous substances	E2,E3,E4

APPENDIX G - NATIONAL RESEARCH COUNCIL RECOMMENDATIONS

In this appendix, those recommendations directed primarily at administrators and supervisors are given in sections A-D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (Reference to page numbers in Prudent Practices are given in parentheses.)

A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B-E, Prudent Practices expresses certain general principles including the following:

A.1 It is prudent to minimize all chemical exposures. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2, 10). Skin contact with chemicals should be avoided as a cardinal rule (198).

A.2 Avoid underestimation of risk. Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10, 37, 38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).

A.3 Provide adequate ventilation. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).

A.4 Institute a chemical hygiene program. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular continuing effort, not merely a standby or short-term activity (6, 11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).

A.5 Observe the PEL's, TLV's. The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded (13).

B. **Chemical Hygiene Responsibilities**

Responsibility for chemical hygiene rests at all levels (6, 11, 21) including the:

B.1 Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).

B.2 Supervisor of the department or other administrative unit, who is responsible for chemical hygiene in that unit (7).

B.3 Chemical hygiene officer(s), whose appointment is essential (7) and who must:

B.3.(a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);

B.3.(b) Monitor procurement, use, and disposal of chemicals used in the lab (8);

B.3.(c) See that appropriate audits are maintained (8);

B.3.(d) Help project directors develop precautions and adequate facilities (10);

B.3.(e) Know the current legal requirements concerning regulated substances (50);

B.3.(f) Seek ways to improve the chemical hygiene program (8, 11).

B.4 Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:

B.4.(a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);

B.4.(b) Provide regular formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);

B.4.(c) Know the current legal requirements concerning regulated substances (50, 231);

B.4.(d) Determine the required levels of protective apparel and equipment (156, 160, 162);

B.4.(e) Ensure that facilities and training for use of any material being ordered are adequate (215).

B.5 Project director or director of other specific operation, who has primary responsibility for chemical hygiene procedures for that operation (7).

B.6 Laboratory worker, who is responsible for:

B.6.(a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7, 21, 22, 230);

B.6.(b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

C.1 Design. The laboratory facility should have:

C.1.(a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);

C.1.(b) Adequate, well-ventilated stockrooms/storerooms (218, 219);

C.1.(c) Laboratory hoods and sinks (12, 162);

C.1.(d) Other safety equipment including eyewash fountains and drench showers (162, 169);

C.1.(e) Arrangements for waste disposal (12, 240).

C.2 Maintenance. Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continuing appraisal and be modified if inadequate (11, 12).

C.3 Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).

C.4 Ventilation.

C.4.(a) *General laboratory ventilation.* This system should: provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (196); it should ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); it should direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).

C.4.(b) *Hoods.* A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.

C.4.(c) *Other local ventilation devices.* Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).

C.4.(d) *Special ventilation areas.* Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).

C.4.(e) *Modifications.* Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).

C.4.(f) *Performance.* Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).

C.4.(g) *Quality.* General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 fm) (200-204).

C.4.(h) *Evaluation.* Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made (12, 195, 207). See pp. 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. **Components of the Chemical Hygiene and Safety Plan**

D.1 Basic Rules and Procedures. Recommendations for these are given in section E below.

D.2 Chemical procurement, Distribution, and Storage.

D.2.(a) *Procurement.* Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).

D.2.(b) *Stockrooms/Storerooms.* Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-219). Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

D.2.(c) *Distribution.* When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).

D.2.(d) *Laboratory storage.* Amounts permitted should be as small as practical. Storage on bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225-226, 229).

D.3 Environmental Monitoring. Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a highly toxic substance is stored or used regularly (e.g., 3 times/week) (13).

D.4 Housekeeping, Maintenance, and Inspections.

D.4.(a) *Cleaning.* Floors should be cleaned regularly (24).

D.4.(b) *Inspections.* Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).

D.4.(c) *Maintenance.* Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Safety showers should be tested routinely (169). Other safety equipment should be inspected regularly (e.g., every 3-6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).

D.4.(d) *Passageways.* Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).

D.5 Medical Program

D.5.(a) *Compliance with regulations.* Regular medical surveillance should be established to the extent required by regulations (12).

D.5.(b) *Routine surveillance.* Anyone whose work involves regular and frequent handling of toxicogically significant quantities of a chemical should consult a qualified physician to determine on an individual bases whether a regular schedule of medical surveillance is desirable (11, 50).

D.5.(c) *First aid.* Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.

D.6. Protective Apparel and Equipment

These should include for each laboratory:

D.6.(a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);

D.6.(b) An easily accessible drench-type safety shower (162, 169);

D.6.(c) An eyewash fountain (162);

D.6.(d) A fire extinguisher (162-164);

D.6.(e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and

D.6.(f) Other items designated by the laboratory supervisor (156, 160).

D.7. Records

D.7.(a) Accident records should be written and retained (174).

D.7.(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).

D.7.(c) Inventory and usage records for high-risk substances should be kept as specified in sections E3e below.

D.7.(d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

D.8. Signs and Labels

Prominent signs and labels of the following types should be posted:

D.8.(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28);

D.8.(b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);

D.8.(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumptions and storage are permitted (25); and

D.8.(d) Warnings at areas or equipment where special or unusual hazards exist (27).

D.9. Spills and Accidents

D.9.(a) A written emergency plan should be established and communicated to all personnel: It should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).

D.9.(b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).

D.9.(c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).

D.9.(d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).

D.10. Information and Training Program

D.10.(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5, 15).

D.10.(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154,169). Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6). Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.

D.10.(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).

D.10.(d) Frequency of Training: The training and education program should be a regular, continuing activity - not simply an annual presentation (15).

D.10.(e) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).

D.11. Waste Disposal Program

D.11.(a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).

D.11.(b) Content (14, 232, 233, 240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. Transport from the institution must be in accordance with DOT regulations (244).

D.11.(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27). Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).

D.11.(d) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).

D.11.(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241). Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14). Hoods should not be used as a means of disposal for volatile chemicals (40, 200). Disposal by recycling (233,243) or chemical decontamination (40, 230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals

The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the sub-programs mentioned above, these should include the rules listed below.

E.1. General Rules The following general rules should be used for essentially all laboratory work with chemicals:

E.1.(a) Accidents and spills

Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention (33, 172).

Ingestion: Encourage the victim to drink large amounts of water (178).

Skin Contact: Promptly flush the affected area with water (33, 172, 178) and remove any contaminated clothing (172, 178). If symptoms persist after washing, seek medical attention (33).

Clean-up: Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24, 33). See pp. 233-237 for specific clean-up recommendations.

E.1.(b) Avoidance of "routine" exposure: Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23); do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199). Inspect gloves (157) and test glove boxes (208) before use. Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

E.1.(c) Choice of Chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate 913).

E.1.(d) Eating, smoking, etc.: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24). Avoid storage, handling or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).

E.1.(e) Equipment and Glassware: Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23, 26).

E.1.(f) Exiting: Wash areas of exposed skin well before leaving the laboratory (23).

E.1(g) Horseplay: Avoid practical jokes or other behavior which might confuse, startle or distract another worker (23).

E.1.(h) Mouth suction: Do not use mouth suction for pipeting or starting a siphon (23, 32).

E.1.(i) Personal Apparel: Confine long hair and loose clothing (23, 158). Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes, or sneakers (158).

E.1.(j) Personal Housekeeping: Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).

E.1.(k) Personal Protection: Assure that appropriate eye protection (154-156) is worn by all persons, including visitors, where chemicals are stored or handled (22, 23, 33, 154).

Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect the gloves before each use, wash them before removal, and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given p. 159).

Use appropriate (164-168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164-5), inspecting the respirator before use (169).

Use any other protective and emergency apparel and equipment as appropriate (22, 157-162).

Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155).

Remove laboratory coats immediately on significant contamination (161).

E.1.(l) Planning: Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22, 23).

E.1.(m) Unattended Operations: Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27, 128).

E.1.(n) Use of Hood: Use the hood for operations which might result in release of toxic chemical vapors or dust (198-9).

As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13). Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200). Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).

E.1.(o) Vigilance: Be alert to unsafe conditions and see that they are corrected when detected (22).

E.1.(p) Waste Disposal: Assure that the plan for each laboratory operation includes plans and training for waste disposal (230).

Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22, 24).

Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (231); or any substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).

E.1(q) Working Alone: Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).

E.2. Working with Allergens and Embryotoxins

E.2.(a) Allergens (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).

E.2.(b) Embryotoxins (34-5) (examples: organomercurials, lead compounds, formamide): If you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel (especially gloves) to prevent skin contact.

Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made. Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.

Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

E.3. Work with Chemicals of Moderate Chronic or High Acute Toxicity

Examples: diisopropylfluorophospate (41), hydrofluoric acid (43), hydrogen cyanide (45). Supplemental rules to be follow in addition to those mentioned above (Procedure B of Prudent Practices, pp. 39-41):

E.3.(a) Aim: To minimize exposure to these toxic substances by any route using all reasonable precautions (39).

E.3.(b) Applicability: These precautions are appropriate for substances with moderate chronic or high acute toxicity used in significant quantities (39).

E.3.(c) Location: Use and store these substances only in areas of restricted access with special warning signs (40, 229).

Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 60 linear feet per minute) (40) or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance (39); trap released vapors to prevent their discharge with the hood exhaust (40).

E.3.(d) Personal Protection: Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

E.3.(e) Records: Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved (40, 229).

E.3.(f) Prevention of Spills and/Accidents: Be prepared for accidents and spills (41).

Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity (39).

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40). If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

E.3.(g) Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40). Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

E.4. Work with Chemicals of High Chronic Toxicity

(Examples: dimethylmercury and nickel carbonyl (48), benzo-a-pyrene (51), N-nitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38).

Further supplemental rules to be followed, in addition to all these mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of Prudent Practices pp. 47-50).

E.4.(a) Access: Conduct all transfers and work with these substances in a "controlled area": a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

E.4.(b) Approvals: Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

E.4.(c) Non-contamination/Decontamination: Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area (49, 50).

Decontaminate the controlled area before normal work is resumed there (50).

E.4.(d) Exiting: On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

E.4.(e) Housekeeping: Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

E.4.(f) Medical Surveillance: If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance (50).

E.4.(g) Records: Keep accurate records of the amounts of these substances stored (229) and used, the dates of use, and names of users (48).

E.4.(h) Signs and Labels: Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and warning labels (48).

E.4.(i) Spills: Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available (233-4).

E.4.(j) Storage: Store containers of these chemicals only in a ventilated, limited access (48, 227, 229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48, 229).

E.4.(k) Glove boxes: For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap the exit gases or filter them through a HEPA filter and then release them into the hood (49).

E.4.(l) Waste: Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49, 50, 233).

E.5. Animal Work with Chemicals of High Chronic Toxicity

E.5.(a) Access: For large scale studies, special facilities with restricted access are preferable (56).

E.5.(b) Administration of the Toxic Substance: When possible, administer the substance by injection or gavage instead of in the diet. If administration is in the diet, use a caging system under negative pressure or under laminar air flow directed toward HEPA filters (56).

E.5.(c) Aerosol Suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55,56).

E.5.(d) Personal Protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jump suit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).

E.5.(e) Waste Disposal: Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

The above recommendations from Prudent Practices do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications to chemical hygiene:

F.1. Corrosive agents: (35-6)

F.2. Electrically powered laboratory apparatus: (179-92)

F.3. Fires, explosions: (26. 57-74. 162-4. 174-5. 219-20. 226-7)

F.4. Low temperature procedures: (26, 88)

F.5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27. 75-101)

G. Material Safety Data Sheets

Material safety data sheets are presented in Prudent Practices for the chemicals listed below. (Asterisks denote that comprehensive material safety data sheets are provided).

APPENDIX G - NATIONAL RESEARCH COUNCIL RECOMMENDATIONS

*Acetyl peroxide (105)
*Acrolein (106)
*Acrylonitrile (107)
Ammonia (anhydrous) (91)
*Aniline
*Benzene (110)
*Benzo(a)pyrene (112)
*Bis(chloromethyl) ether (113)
Boron trichloride (91)
Boron trifluoride (92)
Bromine (114)
*Tert-butyl hydroperoxide (148)
*Carbon disulfide (116)
Carbon monoxide (92)
*Carbon tetrachloride (118)
*Chlorine (119)
Chlorine trifluoride (94)
*Chloroform (121)
Chloromethane (93)
*Diethyl ether (122)
Diisopropylfluorophosphate (41)
*Dimethylformamide (123)
*Dimethyl Sulfate (125)
*Dioxane (126)
*Ethylene dibromide (128)
*Fluorine (95)
*Formaldehyde (130)
*Hydrazine and salts (132)
Hydrofluoric acid (43)
Hydrogen bromide (98)
Hydrogen chloride (98)
*Hydrogen cyanide (133)
*Hydrogen sulfide (135)
Mercury and compounds (52)
*Methanol (137)
*Morpholine (138)
*Nickel carbonyl (99)
*Nitrobenzene (139)
Nitrogen dioxide (100)
N-nitrosodiethylamine (54)
*Peracetic acid (141)
*Phenol (142)
*Phosgene (143)
*Pyridine (144)
*Sodium azide (145)
*Sodium cyanide (147)
Sulfur dioxide (101)
*Trichloroethylene (149)
*Vinyl chloride (150)

APPENDIX G - REFERENCES

29 CFR 1910.1450B Appendix B to 1910.1450

The following references are provided to assist the employer in the development of a Chemical Hygiene and Safety Plan. The materials listed below are offered as non-mandatory guidance. References listed here do not imply specific endorsement of a book, opinion, technique, policy or a specific solution for a safety or health problem. Other references not listed here may better meet the needs of a specific laboratory.

(a) Materials for the development of the Chemical Hygiene and Safety Plan:

(a)1. American Chemical Society, Safety in Academic Chemistry Laboratories, 4th edition, 1985.

(a)2. Fawcett, H.H. and W.S. Wood, Safety and Accident Prevention in Chemical Operations, 2nd edition, Wiley-Interscience, New York, 1982.

(a)3. Flury, Patricia A., Environmental Health and Safety in the Hospital Laboratory, Charles C. Thomas Publisher, Springfield IL., 1978.

(a)4. Green, Michael E. and Turk, Amos., Safety in Working with Chemicals, Macmillan Publishing Co., NY, 1978.

(a)5. Kaufman, James A., Laboratory Safety Guidelines, Dow Chemical Co., Box 1713, Midland, ML 48640, 1977.

(a)6. National Institutes of Health, NIH Guidelines for the Laboratory use of Chemical Carcinogens, NIH Pub. No. 81-2385, GPO, Washington, DC 20402, 1981.

(a)7. National Research Council, Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, DC, 1983.

(a)8. National Research Council, Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, DC, 1981.

(a)9. Renfrew, Malcolm, Ed., Safety in the Chemical Laboratory, Vol. IV. J. Chem. ED., American Chemical Society, Easlon, PA, 1981.

(a)10. Steere, Norman V., ED., Safety in the Chemical Laboratory, J. Chem. Ed., American Chemical Society, Easlon, PA 18042, Vol. I. 1967. Vol II. 1971, Vol III. 1974.

(a)11. Steere, Norman V., Handbook of Laboratory Safety, The Chemical Rubber Company, Cleveland, OH, 1971.

(a)12. Young, Jay A., Ed., Improving Safety in the Chemical Laboratory, John Wiley & Sons, Inc. New York, 1987.

(b) Hazardous Substances Information:

(b)1. American Conference of Governmental Industrial Hygienists Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, P.O. Box 1937, Cincinnati, OH 45201 (latest edition).

(b)2. Annual Report on Carcinogens, National Toxicology Program U.S. Department of Health and Human Services. Public Health Service U.S. Government Printing Office, Washington, DC, (latest edition).

(b)3. Best Company, Best Safety Directory, Vols. I and II. Oldwick, N.J., 1981.

(b)4. Bretherick, L., Handbook of Reactive Chemical Hazards, 2nd edition, Butterworths, London, 1979.

(b)5. Bretherick, L., Hazards in the Chemical Laboratory, 3rd edition, Royal Society of Chemistry, London, 1986.

(b)6. Code of Federal Regulations, 29 CFR part 1910 subpart Z. U.S. Government Printing Office, Washington, DC, 20402 (latest edition).

(b)7. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, World Health Organization Publications Center, 49 Sheridan Avenue Albany, New York 12210 (latest edition).

(b)8. NIOSH/OSHA Pocket Guide to Chemical Hazards, NIOSH Pub. No. 85-114. U.S. Government Printing Office, Washington, DC, 1985 (or latest edition).

(b)9. Occupational Health Guidelines, NIOSH/OSHA NIOSH Pub. No. 81-123 U.S. Government Printing Office, Washington, DC, 1981.

(b)10. Patty, F.A., Industrial Hygiene and Toxicology, John Wiley & Sons, Inc. New York, NY (five volumes).

(b)11. Registry of Toxic Effects of Chemical Substances, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. Revised Annually, for sale from Superintendent of Documents U.S. Government Printing Office, Washington, DC, 20402.

(b)12. The Merck Index: An Encyclopedia of Chemicals and Drugs, Merck and Company, Inc. Rahway, N.J., 1976 (or latest edition).

(b)13. Sax, N.I., Dangerous Properties of Industrial Materials, 5th edition. Van Nostrand Reinhold, N.Y., 1979. Sittig, Marshall. Handbook of Toxic and Chemicals. Noyes Publications, Park Ridge, N.J., 1981.

(c) Information on Ventilation:

(c)1. American Conference of Governmental Industrial Hygienists Industrial Ventilation, 16th edition Lansing, ML, 1980.

(c)2. American National Standards Institute, Inc., American National Standards Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z 9.2-1979 American National Standards Institute. N.Y., 1979.

(c)3 Imad, A.P. and Watson, C.L., Ventilation Index: An Easy Way to Decide about Hazardous Liquids, Professional Safety pp 15-18. April 1980.

(c)4. National Fire Protection Association, Fire Protection for Laboratories Using Chemicals, NFPA-45, 1982; Safety Standards for Laboratories in Health Related Institutions, NFPA 56c; 1980 Fire Protection Guide on Hazardous Materials, 7th edition, 1978; National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

(c)5. Scientific Apparatus Makers Association (SAMA), Standards for Laboratory Fume Hoods, SAMA LF7-1980, 1101 16th Street, NW., Washington, DC 20036.

(d) Information on Availability of Referenced Material:

(d)1. American National Standards Institute (ANSI). 1430 Broadway, New York, NY 10018.

(d)2. American Society for Testing and Materials (ASTM). 1916 Race Street, Philadelphia, PA 19103.

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