

**NOVA SOUTHEASTERN
UNIVERSITY**

ENVIRONMENTAL
HEALTH AND
SAFETY

POLICY/PROCEDURE

TITLE: Chemical Hygiene Plan

POLICY/PROCEDURE

NUMBER: 3

DOCUMENT HISTORY

OWNER:	Facilities Management/AHIS		Date: 1 Sept 2011
APPROVED:	NSU EH&S Committee		Date: 1 Sept 2013
IMPLEMENTED:			Date: 1 Oct 2010
RETIRED:			Date:
<u>Date:</u>	<u>Revision No.</u>	<u>Review / Changes</u>	<u>Reviewer</u>
7 August 2013	none		

Distribution: The current version is available via NSU intranet. Paper copies of this document require prior approval before printing

TABLE OF CONTENTS

Section 1:	Introduction	Page	4
Section 2:	Chemical Safety Guidelines	Page	7
Section 3:	Chemical Hygiene Responsibilities	Page	9
Section 4:	Exposure Assessments and Medical Surveillance	Page	12
Section 5:	Material Safety Data Sheets - MSDS	Page	16
Section 6:	Chemical Labels	Page	17
Section 7:	Hazard Communication	Page	18
Section 8:	Permissible Exposure Limits	Page	21
Section 9:	Engineering Controls	Page	22
Section 10:	Classification of Hazardous Substances	Page	32
Section 11:	Chemical Handling and Storage	Page	47
Section 12:	Chemical Inventory	Page	61
Section 13:	Compressed Gas Safety	Page	62
Section 14:	Spill Response and Clean-up Guidelines	Page	65
Section 15:	Shipping / Receiving Chemicals	Page	69
Section 16:	Training	Page	70
Section 17:	Record Keeping	Page	72
Section 18:	Chemical Waste Disposal	Page	73

Tables and Illustrations

Table A:	General Classes of Fires and Fire Extinguishers	Page	23
Table B:	Flammable and Combustible Liquids Class Characteristics	Page	35
Table C:	Solvent Substitutions	Page	37
Table D:	Common Cleaning Agents/Hazards/Precautions	Page	45
Table E:	Shelf Life of Unstable Chemicals	Page	61
Table F:	Types of Chemical Spills	Page	65
Table G:	Record Keeping	Page	72
Table H:	Chemical Substitutions	Page	78
Illustration 1:	NFPA System for Classification of Hazards	Page	17

Appendices

Appendix A:	Laboratory Decommissioning Checklist	Page	79
Appendix B:	Material Safety Data Sheets	Page	81
Appendix C:	HMIS - Hazardous Materials Identification System	Page	85
Appendix D:	Chemical Storage and Labeling	Page	78
Appendix E:	Hazard Communication - Employee Training Certification	Page	89
Appendix F:	Eyewash Maintenance Weekly Log Sheet	Page	90
Appendix G:	Personal Protective Equipment Types	Page	91
Appendix H:	Hazard Assessment Form	Page	92
Appendix I:	Glove Selection Chart	Page	94
Appendix J:	Common Laboratory Corrosives	Page	95

CHEMICAL HYGIENE PLAN

Appendix K: Common Laboratory Oxidizers	Page 96
Appendix L: Classes of Peroxidizable Chemicals	Page 97
Appendix M: OSHA Regulated Carcinogens	Page 99
Appendix N: Incompatible Chemicals	Page 100
Appendix O: Listed Hazardous Waste	Page 101
Appendix P: EPA Uniform Hazardous Waste Manifest	Page 103
Appendix Q: Table Z-1 Limits of Air Contaminants	Page 104
Appendix R: Table Z-2 Limits of Air Contaminants	Page 119
Appendix S: Table Z-3 Mineral Dusts	Page 120

Section 1: Introduction

Nova Southeastern University is committed to establishing and maintaining safe and healthy working conditions and to promote safe practices by all staff, faculty and students. The University is also committed to working in ways that reflect its deep concern for its neighbors and for the quality of the surrounding environment.

The goals of implementing the Chemical Hygiene Plan include:

1. Minimizing the risk of chemical exposure;
2. Minimizing the risk of work-related injury and illness;
3. Minimizing the risk to the environment;
4. Compliance with applicable regulations and standards;
5. Achievement of goals with a minimum burden on research and clinical activities.

The Occupational Safety and Health Administration (OSHA), a part of the Department of Labor, administers a variety of regulations and published in and referred to as the Code of Federal Regulations (CFR). Part 1910 of Title 29 (cited as "29 CFR 1910"), section 1450 of subpart Z, "Occupational Exposures to Hazardous Chemicals in Laboratories", referred to as the "Laboratory Standard", and specifically addresses mandated regulatory requirements.

An effective chemical hygiene plan necessitates that mechanisms be in place and functioning to ensure that safety policies and procedures are being adhered to; personnel are meeting their safety responsibilities; and an effective form of monitoring and documentation is in place for confirmation purposes. Chemical safety is inherently linked to other safety issues including laboratory procedures, personal protective equipment, electrical safety, fire safety, and hazardous waste disposal.

The development of a detailed written chemical hygiene plan and the implementation of this plan within employee and student training programs should result in a safer working environment and contribute to a reduction in work place accidents and injuries.

1.1 Scope

Almost everyone works with or around chemicals and chemical products every day. Many of these materials have properties that make them hazardous, i.e. they can create physical (fire, explosion) and/or health hazards (toxicity, chemical burns). There are many ways to work with chemicals which can both reduce the probability of an accident to a negligible level and reduce the consequences to minimum levels should an accident occur. Risk minimization depends on safe practices, appropriate engineering controls for chemical containment, the proper use of personal protective equipment, the use of the least quantity of material necessary, and substitution of a less hazardous chemical for the more hazardous one. Before beginning an operation, ask "What would happen if...?" The answer to this question requires an understanding of the hazards associated with the chemicals, equipment and procedures involved. The hazardous properties of the material and intended use will dictate the precautions to be taken.

Another important distinction is the difference between hazard and risk. The two terms are sometimes used as synonyms. In fact, hazard is a much more complex concept because it includes conditions of use.

The hazard presented by a chemical has two components: (1) its inherent capacity to do harm by virtue of its toxicity, flammability, explosiveness, corrosiveness, etc., and (2) the ease with which the chemical can come into contact with a person or other object of concern. The two components together determine risk (the likelihood or probability that a chemical will cause harm). Thus, an extremely toxic chemical such as strychnine cannot cause poisoning if it is in a sealed container and does not contact the handler. In contrast, a chemical that is not highly toxic can be lethal if a large amount is ingested.

Knowledge + Common Sense + Caution = Chemical Safety

Not all chemicals are considered hazardous. Examples of nonhazardous chemicals include buffers, sugars, starches, agar, and naturally occurring amino acids.

1.2 Definitions

Action level: A concentration 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. Typically it is one-half that of the PEL for that substance.

Acute: Severe, often dangerous conditions in which relatively rapid changes occur.

Carcinogen: Any substance that causes the development of cancerous growths in living tissue, either those that are known to induce cancer in man or animals or experimental carcinogens that have been found to cause cancer in animals under experimental conditions.

Designated Area: An area which may be used for work with select carcinogens, reproductive toxins, or substances which have a high degree of acute toxicity.

Health Hazard: A substance 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 if exposed. This term includes carcinogens, toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, and neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

MSDS (Material Safety Data Sheets): Formal document containing important information about the characteristics and actual or potential hazards of a substance. It identifies the manufacturer of the material (with name, address, phone, and fax number) and usually includes (1) chemical identity, (2) hazardous ingredients, (3) physical and chemical properties, (4) fire and explosion data, (5) reactivity data, (6) health hazards data, (7) exposure limits data, (8) precautions for safe storage and handling, (9) need for protective gear, and (10) spill control, cleanup, and disposal procedures.

PEL (Permissible Exposure Limit): An exposure limit that is published and enforced by OSHA as a legal standard. PEL may be either a time-weighted-average (TWA) exposure limit (8 hour), a 15-minute short term exposure limit (STEL) or a ceiling (C). The PELs are found in Tables Z-1, Z-2, or Z-3 of 29 CFR 1910.1000 (see Appendix Q, R, and S). This level of exposure is deemed to be the maximum safe concentration and is generally the same value as the threshold limit value (TLV).

PPE (Personal Protective Equipment); Any devices or clothing worn by personal to protect against hazards in the environment. Examples are respirators, gloves, and chemical splash goggles.

Respirator; A device which is designed to protect the wearer from inhaling harmful contaminants.

STEL (Short Term Exposure Limit): Represented as STEL or TLV-STEL, this is the maximum concentration to which personal can be exposed for a short period of time (15 minutes) for only four times throughout the day with at least one hour between exposures.

Time Weighted Average: The time weighted average airborne chemical concentration for a normal eight hour work day and a 40 hour work week to which nearly all personal may be repeatedly exposed, day after day, without adverse effect.

TLV (Threshold Limit Value): Airborne concentrations of substances devised by the ACGIH that represents conditions under which it is believed that nearly all workers may be exposed day after day with no adverse effect. TLVs are advisory exposure guidelines, not legal standards that are based on evidence from industrial experience, animal studies, or human studies when they exist.

Toxic: Substances such as carcinogens, irritants, or poisonous gases, liquids, and solids which are irritating to or affect the health of humans.

Section 2: Chemical Safety Guidelines

All staff, faculty and students shall follow standard work practices and guidelines when handling hazardous materials. Standard work practices include, but are not limited to, the following general safety-related practices:

- a. Process for chemical selection;
- b. Hazard identification;
- c. Selection and use of PPE
- d. Control of emissions to the environment
- e. Prevention of spills and accidents
- f. Storage practices
- g. Disposal of wastes
- h. Termination of work

Always follow these standard guidelines when working with chemicals:

- a. Assume that any unfamiliar chemical is hazardous and treat all chemicals and equipment with caution and respect.
- b. Never perform hazardous operations alone in a laboratory or chemical storage area.
- c. Know all the hazards of the chemicals with which you work. For example, perchloric acid is a corrosive, an oxidizer, and a reactive. Benzene is an irritant that is also flammable, toxic, and carcinogenic.
- d. Remove and use only the amount of chemicals needed for the immediate job at hand.
- e. Consider any mixture to be at least as hazardous as its most hazardous component.
- f. Never use any substance that is not properly labeled. Properly seal, and store chemicals in appropriate containers. Keep the container clearly marked and in a well-ventilated area.
- g. Follow all chemical safety instructions precisely.
- h. Check stored chemicals for deterioration and broken containers.
- i. Ensure that sources of ignition are not close or nearby when working with flammable materials. This will prevent a fire or explosion if a vapor release or liquid spill occurs.
- j. Use a tip-resistant shield for protection in case an explosion or implosion occurs.
- k. Minimize your exposure to any chemical, regardless of its hazard rating.
- l. Use personal protective equipment at all times.
- m. Clean up spills and leaks immediately.
- n. Know what to do in an emergency.
- o. Learn how to dispose of chemicals safely and legally. Follow Nova Southeastern University waste disposal requirements.
- p. Use common sense at all times.

Likewise, when working with chemicals, remember the following:

- a. Do not store chemicals near heat or sunlight or near substances which might initiate a dangerous reaction.

CHEMICAL HYGIENE PLAN

- b. Do not transport unprotected chemicals between the work area and other areas. Use a tray, rack, cart or rubber carrier. Always use a secondary container when transporting hazardous or highly odorous chemicals on an elevator.
- c. Do not pour hazardous chemicals down the sink.
- d. Do not put fellow workers or yourself in danger.

The five prudent practices of chemical safety sum up these safety guidelines:

- 1. Treat all chemicals as if they were hazardous.
- 2. Minimize your exposure to any chemical.
- 3. Avoid repeated exposure to any chemical.
- 4. Never underestimate the potential hazard of any chemical or combination of chemicals.
- 5. Assume that a mixture or reaction product is more hazardous than any component or reactant.

2.1 Hygiene and Chemical Safety

Good personal hygiene will help minimize exposure to hazardous chemicals. When working with chemicals, follow these guidelines:

- a. Wash hands frequently and before leaving the laboratory. Also, wash hands before eating, drinking, smoking, or applying makeup.
- b. Remove contaminated clothing immediately. Do not use the clothing again until it has been properly decontaminated.
- c. Follow any special precautions for the chemicals in use.

In addition the following special precautions should be taken:

- a. Do not eat, drink, smoke, or apply makeup around chemicals.
- b. Do not wear contact lenses near chemicals, especially corrosives or volatile solvents.
- c. Do not keep food or food containers anywhere near chemicals.
- d. Do not use laboratory equipment to serve or store food or drinks.
- e. Do not sniff or taste chemicals.

Section 3: Chemical Hygiene Responsibilities

Nova Southeastern University has certain obligations pursuant to local, state and federal regulations. Responsibility for chemical hygiene rests at all levels including, but not limited to, the supervisor of a College, Department or other administrative unit; departmental chemical and safety officers; and laboratory staff and students.

The University President has ultimate responsibility for chemical hygiene within Nova Southeastern University and must, with other administrators, provides continuing support for University chemical hygiene.

3.1 The Office of Environmental Health and Safety

The Environmental Health and Safety Office (EH&S) shall ensure this Chemical Hygiene Plan (CHP) is enforced and at a minimum perform the below tasks:

- a. Provide technical support and assistance including chemical, hazardous waste, biological, industrial hygiene, fire/life safety and environmental stewardship.
- b. Develop and implement educational programs designed to improve the health and safety of the University community and to foster compliance with governmental regulations and professional standards.
- c. Provide training and information regarding chemical and physical hazards.
- d. Conduct regular surveys to the campus departments and assist in compliance with the Chemical Hygiene Plan.
- e. Keep records of staff, faculty and student exposures to hazardous chemicals:
 - i. Records should include measurements made to monitor exposures, if any, as well as any medical consultations and examinations, including written opinions.
 - ii. Maintain these records as mandated in 29 CFR 1913.1020, Access to Employee Exposure and Medical Records.
- f. For incoming hazardous chemicals:
 - i. Require that the incoming hazardous chemicals have adequate labels. Labels are not removed or defaced.
 - ii. Require that the MSDSs for incoming hazardous chemicals be on hand prior to receipt of hazardous chemicals whenever possible.
 - iii. Maintain an accurate inventory of all chemicals in Nova Southeastern University laboratories.
- g. When hazardous chemicals are generated in Nova Southeastern University laboratories:
 - i. If the hazardous properties are known, train University staff, faculty and students.
 - ii. If the hazardous properties are not known, treat the chemical as though it is hazardous and provide protection as described in this Chemical Hygiene Plan.
 - iii. If the chemicals are produced for use elsewhere, follow 29 CFR 1910.1200 and the various Environmental Protection Agency (EPA) and Department of Transportation (DOT) regulations that apply to that chemical.
- h. If there is reason to believe that the action level, or PEL if there is no action level, has been exceeded for any chemical for which a substance-specific standard has been established, the University must measure the concentration of that chemical in the air.

CHEMICAL HYGIENE PLAN

- i. If the level measured is greater than the PEL or action level, then notify all affected laboratory personnel of the results of the measurement, and comply with the OSHA exposure-monitoring provisions for that chemical, as stated in 29 CFR 1910.1000 through 1910.1096.
- i. If respirators are necessary to keep exposures below the PEL or action level, follow the requirements of the Respiratory Protection Standard, 29 CFR 1910.134.
- j. If select carcinogens, reproductive toxins, or acute toxins that are very highly toxic are used in the laboratory, identify and post one or more areas as "designated area(s)."
- k. Require that each University Department or similar University administration unit which has laboratories, have a Chemical and Safety Officer.
 - i. These individuals should be qualified by training and experience to provide technical guidance in the development and implementation of the Chemical Hygiene Plan.
 - ii. The University President has the ultimate responsibility for chemical safety. The Department Chemical and Safety Officers act as the representative of the University President in this capacity.
- l. Develop and implement educational programs designed to improve the health and safety of the University community and to foster compliance with governmental regulations and professional standards.

3.2 Departmental Chemical and Safety Officers.

Departmental Chemical and Safety Officers have overall responsibility for chemical hygiene in all departmental laboratories. These responsibilities include, but are not limited to:

- a. Work with administrators and other personnel to develop and implement appropriate chemical hygiene policies and practices;
- b. Ensure that all staff and students know and follow the chemical hygiene rules and document that appropriate training has been provided;
- c. Determine the required levels of protective apparel and equipment and insure that this equipment is available and in working order;
- d. Monitor procurement, use, and disposal of chemicals;
- e. Ensure that EH&S receive copies of all MSDSs received;
- f. Maintain an accurate Departmental chemical Inventory List. A copy is filed with EH&S;
- g. Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment;
- h. Know the current legal requirements concerning regulated substances.
- i. Arrange for immediate emergency response, if necessary, for chemical spills, injuries and over-exposures;
- j. Identify the location of the nearest safety equipment and posting the list in a conspicuous place in the laboratory or storage area;
- k. Ensuring proper signage inside the laboratory and storage areas where hazards may exist;
- l. Completing Vacating Procedures prior to any laboratory renovation or departure. See Appendix A: Laboratory Decommissioning Checklist.

3.3 Laboratory staff and students

Laboratory staff and students are responsible for:

- a. Knowing where the Laboratory Chemical Hygiene Plan is, reviewing it and familiar with their responsibility.
- b. Refrain from performing any function or operation, which is considered hazardous or is known to be hazardous, without proper instruction and authorization.
- c. Comply with applicable environmental health and safety policies, standards, rules, regulations, and procedures. These include safety-related signs, posters, warnings and written / oral directions when performing tasks.
- d. Knowing where the MSDS manual is located.
- e. Inform the Chemical and Safety Officer immediately of all work-related injuries or accidents and obtain prompt medical attention when necessary.
- f. Attend Safety handling and disposing of chemicals.
- g. Sharing responsibility to ensure all chemical containers are labeled and kept closed.
- h. Use the appropriate PPE when working with chemicals in the laboratory and storage areas.
- i. Develop and maintain good personal chemical hygiene habits.
- j. Report all unsafe conditions, practices, or equipment to the Chemical and Safety Officer.

Section 4: Exposure Assessments and Medical Surveillance

4.1 Suspected Exposures

There may be times when a staff member or supervisor suspects that an employee/student has been exposed to a hazardous chemical to a degree and in the manner that may cause harm to the individual. If there is a reasonable suspicion of exposure, the employee/student is entitled to a medical consultation and, if so determined in the consultation, also to a medical examination. All medical examinations and consultations shall be provided without cost to the employee or student; without loss of pay; and at a reasonable time and place.

1. Reasonable Suspicion of Exposure

Below outlines the recommended process in conducting an assessment when there is a suspicion of exposure to hazardous chemicals:

- a. Investigate all reported incidents in which there is even a remote possibility of an employee or student overexposure to a toxic substance.
- b. Events or circumstances that might reasonably constitute overexposure include:
 - i. A hazardous chemical leaked, spilled or was otherwise rapidly released in an uncontrolled manner.
 - ii. Air monitoring indicates concentrations of contaminants exceed the PEL or TLV.
 - iii. A laboratory employee or student had direct skin or eye contact with a hazardous chemical.
 - iv. A laboratory employee or student develops signs and symptoms, such as headache, rash, nausea, coughing, irritation or redness of eyes, dizziness, irritation of nose or throat, loss of motor dexterity or judgment, etc., these symptoms disappear when the person is away from the exposure area and breaths fresh air.
 - v. Two or more persons in the same laboratory or storage area have similar complaints.

2. Exposure Known

The purpose of an exposure assessment is to determine that there was, or was not, an exposure that might have caused harm to one or more persons and, if so, to identify the hazardous chemical or chemicals involved. Other investigations might well use results and conclusions from an exposure assessment, along with other information, to derive recommendations that will prevent or mitigate any future overexposures.

In the event of a chemical exposure/large spill and an employee(s) or student(s) is injured requiring immediate medical treatment, the exposure assessment to determine how this accident occurred and the corrective action plan can be performed, post medical treatment. In the case of a non-emergency or minor injury which can be treated onsite (eyes flushed or minor burn), the exposure assessment can be filled out before the injured party is sent for a medical consultation, if necessary.

Recommended process when conducting an exposure assessment:

- a. Interview the complainant and also the employee/student, if not the same person.
- b. List the essential information about the circumstances of the complaint, including:
 - i. The chemical under suspicion
 - ii. Other chemicals used by employee/student.
 - iii. All chemicals being used by others in the immediate area.
 - iv. Other chemicals stored in that area.
 - v. Symptoms exhibited or claimed by the individual.
 - vi. How do these symptoms compare to symptoms stated in the materials safety data sheets for each of the identified chemicals.
 - vii. Were control measures, such as PPE and hoods, used properly?
 - viii. Were any air sampling or monitoring devices in place? If so, are the measurements obtained from these devices consistent with other information?
- c. Monitor or sample the air in the area for suspect chemicals.
- d. Determine whether the employee/student's symptoms compare to the symptoms described in the MSDS or other pertinent scientific literature.

The affected employee/student must be notified of the results of monitoring within 15 working days of receipt of the results of any monitoring completed.

4.2 Medical Consultation and Examination

The purpose of a medical consultation is to determine whether a medical examination is warranted. When, from the results of an Exposure Assessment, it is suspected or known that an employee / student was overexposed to a hazardous chemical or chemicals, the employee / students should obtain medical consultation from or under the direct supervision of a licensed physician. A medical consultation should be obtained when the following occurs:

- a. Employee / student develop signs or symptoms associated with a hazardous chemical exposure.
- b. Monitoring, routine or otherwise, suggests that there could have been an exposure above the action level, or OSHA PEL.
- c. There is a spill, leak, or other uncontrolled release of a hazardous chemical.

An employee/student must provide the physician with the following information for purposes of the medical consultation:

- a. The identity of the hazardous chemical or chemicals to which the employee / student may have been exposed.
- b. The exposure conditions.
- c. The signs and symptoms of exposure the individual is experiencing, if any.

Following the medical consultation, the physician will furnish a written opinion of the consultation within 15 days to Nova Southeastern University. This written opinion shall include the following information:

CHEMICAL HYGIENE PLAN

- a. Recommendations for follow-up, if determined to be pertinent.
- b. A record of the results of the consultation and, if applicable, of the examination and any tests that were conducted.
- c. Conclusions concerning any other medical condition noted that could put employee /student at increased risk.
- d. A statement that the employee / student has been informed both of the results of the consultation or examination and of any medical condition that may require further examination or treatment.

When warranted, following an initial medical consultation, employees / students may also be required to receive a medical examination from or under the direct supervision of a licensed physician who is experienced in treating individuals of chemical overexposure. The medical professional should also be knowledgeable about which tests or procedures are appropriate to determine if there has been an overexposure; these diagnostic techniques are called "differential diagnoses." Physician written statements and records for purposes of exposure assessment should not reveal specific findings that are not related to an occupational exposure.

The purpose of a medical consultation is to determine whether a medical examination is warranted. When, from the results of an Exposure Assessment, it is suspected or known that an employee / student was overexposed to a hazardous chemical or chemicals, the employee/students should obtain medical consultation from or under the direct supervision of a licensed physician.

When warranted, employees / students also should receive a medical examination from or under the direct supervision of a licensed physician who is experienced in treating victims of chemical overexposure. The medical professional should also be knowledgeable about which tests or procedures are appropriate to determine if there has been an overexposure; these diagnostic techniques are called "differential diagnoses."

These provisions apply to medical consultations and examinations:

1. When the following occurs:
 - a. Employee / student develop signs or symptoms associated with a hazardous chemical exposure.
 - b. Monitoring, routine or otherwise, suggests that there could have been an exposure above the action level, or OSHA PEL.
 - c. There is a spill, leak, or other uncontrolled release of a hazardous chemical.
2. Provide the physician with:
 - a. The identity of the hazardous chemical or chemicals to which the employee / student may have been exposed.
 - b. The exposure conditions.
 - c. The signs and symptoms of exposure the victim is experiencing, if any.

CHEMICAL HYGIENE PLAN

3. The physician will furnish a written opinion of the consultation within 15 days to Nova Southeastern University and shall include the following information:
 - a. Recommendations for follow-up, if determined to be pertinent.
 - b. A record of the results of the consultation and, if applicable, of the examination and any tests that were conducted.
 - c. Conclusions concerning any other medical condition noted that could put employee /student at increased risk.
 - d. A statement that the employee / student has been informed both of the results of the consultation or examination and of any medical condition that may require further examination or treatment.
4. These written statements and records should not reveal specific findings that are not related to an occupational exposure.

Employees /students shall be notified of the results of any medical consultation or examination with regard to any medical condition that exists or might exist as a result of the overexposure to a hazardous chemical

All memos, notes, and reports related to a complaint of actual or possible exposure to hazardous chemicals are to be maintained separate from the employee/student records.

Section 5: Material Safety Data Sheets - MSDS

The Occupational Safety and Health Administration (OSHA) require that all chemical manufacturers, wholesalers and distributors provide Material Safety Data Sheets (MSDS) for the products which they produce and sell. Typically, MSDS are shipped with the chemical order, or alternatively you may contact the manufacturer to request one or the distributors have MSDS available on their websites. See Appendix B for an example of a MSDS. OSHA requires that employers maintain in the workplace, copies of the MSDS for each hazardous chemical.

Before using any chemical, employees/students should read the container label and the appropriate MSDSs. Container labels and MSDSs are good sources of information for chemical safety and provide the following information:

- Hazardous ingredients
- Exposure limits
- Physical and chemical characteristics, including the following:
 - Boiling point
 - Vapor pressure
- Physical hazards, including the following:
 - Flammability
 - Explosives
 - Reactivity
- Health hazards, including chemicals that are:
 - Toxic
 - Carcinogens
 - Irritants
- First-aid procedures
- Proper leak, spill, and disposal techniques
- Proper storage and handling procedures
- Other special provisions

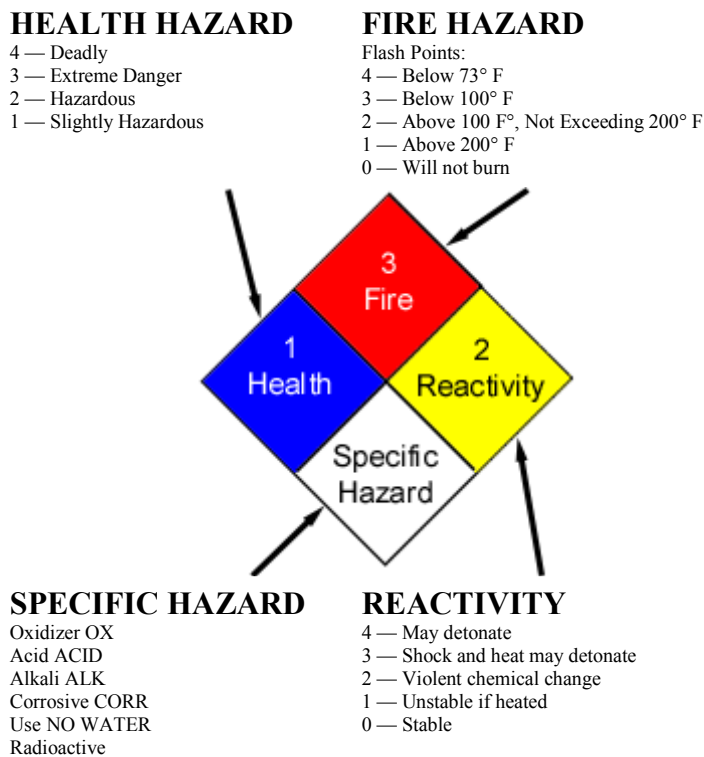
Section 6: Chemical Labels

Labels on chemical containers can be a very useful source of information. Chemical manufacturers are required by the Hazard Communications Standard (29 CFR 1910.1200) to list at the very least their name and address, the chemical's name, and the potential hazards associated with the chemical's use on every container they ship. Most chemical manufacturers also include additional information such as the physical properties, and emergency first aid measures on the label.

Laboratory personnel who use chemicals should be conscientious about the labeling of chemical containers. The OSHA Lab Standard states "employers shall ensure that labels on incoming containers of hazardous chemicals are not removed, or defaced." See, 29 CFR 1910.1450. What this means for laboratories is that containers where solvents, other chemicals, or aging has damaged the label should be re-labeled. All containers in which small amounts of chemicals are kept for temporary purposes must be labeled as well; however, in this case only the name of the chemical and the hazard class is necessary.

The NFPA diamond is a symbol used to identify the hazards associated with a given chemical to rescue workers. Frequently this symbol is found on the sides of buildings where chemicals are stored and on chemical containers. Illustrated below are the various hazards symbolized by the diamond and the numerical code which indicates the severity of the hazard.

Illustration 1: NFPA System for Classification of Hazards



Section 7: Hazard Communication

The Hazard Communication Standard was developed to protect employees when handling or using hazardous chemicals. The standard states that employees have the right to know about the hazards of the chemicals and products with which they work and to promote a safe and healthy workplace. Applicable regulations are OSHA 29 CFR 1910.1200; Hazard Communication Standard (HCS) or Right to Know (RTK) regulation; the State Department of Commerce; and the Environmental Protection Agency (CFR Part 370; Community Right to Know Standard (SARA) and Emergency Plan. Each state, under the authority of the Department of Commerce, has adopted a hazard communication standard identical to the federal standard.

The Right-to-Know Law requires a written Hazard Communication Program (HCP) that communicates to the employees their rights under the regulation and describes how the program is administered at their workplace. The HCP can be divided into five parts:

1. Written program
2. Hazard inventory and hazard determination
3. Material Safety Data Sheets (MSDSs) for all chemicals
4. Labeling of all hazardous chemicals and other forms of warning signs
5. Informing and training of employees

7.1 Written Program

The written hazard communication program which the chemical hygiene plan is part of must be available to all employees / students. A poster explaining the employees' Right-to-Know Law must be posted and visible to all employees /students. The Right-to-Know posters are available from ones State department or a commercial supplier.

7.2 Hazardous Chemical Inventory

The chemical and safety officer or laboratory supervisor is required to maintain an inventory of all hazardous chemicals present in each department and this list is to be updated as necessary. The inventory is part of the HCP and must identify each chemical by the primary name on the label and the manufacturer. In addition, the inventory must identify the location of the chemical and the quantities on hand. The master chemical inventory and MSDS lists will be updated periodically and retained for a period of thirty (30) years.

7.3 Labeling

All chemicals are to be labeled correctly with the chemical identity, appropriate physical and health hazard warnings and the name and address of the manufacturer, importer or other responsible party (OSHA 29 CFR 1910.1200 [d] [2]). Labels and other form of warning must be legible and in English. When chemicals are transferred to another container, all label information must be placed on the new container and the concentration of the working solution if

CHEMICAL HYGIENE PLAN

applicable. All bottles and containers even those with cleaning solutions must be identified by name on the label. Incoming chemicals must not have their labels defaced in any way or removed unless the container is immediately relabeled with the appropriate information.

Secondary containers will be labeled with the trade and/or chemical name and hazard warning information. Chemicals stored in bulk quantities or storage tanks require adequate labeling while storage tanks or drums can be labeled collectively rather than individually as long as they are not removed from the labeled area and if the hazards are the same.

7.4 Signage

The laboratory and chemical storage areas must have correct signage to identify hazardous areas. This identification of hazardous materials must be reviewed and updated annually by the safety officer and documented in the safety audit. The NFPA 704 hazard placard (see Appendix D) should be placed on the doors of areas that contain hazardous materials. Hazard signs for the laboratory should include radioactive, biological, and fire hazards.

OSHA requires color-coded signs at eyewash stations, safety showers, fire extinguishers and emergency exits. All refrigerators/freezers containing hazardous materials, chemical storage cabinets, equipment use for biological material and radioactive areas must have hazardous warning signs.

Waste containers for biological waste should be red with a clearly visible biohazardous sign on the outside. Other containers which require color-coded signage include chemotherapy waste containers (yellow) and recycled containers (normally blue). See Appendix D for examples of hazard warning signs.



7.5 Training

All employees/students will be provided with information and training on hazardous chemicals and this can be conducted in three stages. The first two stages are mandatory and the third should be conducted within a three year period.

The initial stage is part of orientation for new hires (and new students where applicable) and must include general information about chemical safety and the Right-to-Know Law. The second phase is conducted by the chemical and safety officer or supervisor in the workplace and includes, but is not limited to:

- a. Identification of all chemical hazards in the workplace.
- b. The location and availability of the HCP, chemical inventory, MSDS, the chemical hygiene and emergency response SOP's.
- c. Explanation of the hazard labeling requirements, the NFPA Hazard Rating System and the contents of the MSDS and how to use this information.
- d. Measures employees are to take to protect themselves, instructions on safety equipment and the correct use of PPE's.

The last stage is an annual up-date on new hazardous chemicals or procedures and a refresher on safe chemical handling and emergency response.

All training shall be documented and maintained in the employee/student's file. Appendix E is an example of a certificate that can be used to verify employee training.

7.6 Community Right-To-Know Emergency Planning

Laboratories and research departments must comply with the Environmental Protection Agency's (EPA) Emergency Planning and Community Right-to-Know Act (EPCRA) requirements. Local and state organizations may request information about the presence of hazardous chemicals in your laboratory. The EPA must be notified in the event the amount of hazardous chemicals in the laboratory equals or exceeds the threshold planning quantity for particular chemicals, and must be notified of the quantities. The local fire department must be notified of the location of hazardous chemicals which exceed reporting quantities and supplied with MSDSs as necessary to ensure a safe and adequate response in an emergency situation.

Section 8: Permissible Exposure Limits

Exposure limits are the amount or dose of a chemical that an employee/student's body is exposed to which will determine the body's response and adverse effects. A workplace exposure limit is an airborne concentration of a chemical listed by OSHA in 29 CFR 1910.1000, Subpart Z based on an eight-hour-time-weighted average (TWA) that will initiate exposure monitoring and medical surveillance.

The legal limits for workplace exposures are expressed as Permissible Exposure Limits (PEL) or Action Levels (AL) and shall not be exceeded in an eight-hour-working period. OSHA has also promulgated short term exposure limits (STELs) for some chemical agents that are based on a maximum exposure over a fifteen minute period. If the initial monitoring for chemical exposure is performed and the levels are greater than the AL (typically one-half of the PEL), a monitoring program has to be established. This monitoring will continue until the exposure level in the workplace is below the PEL and employees will be notified of the monitoring results within 15 working days.

Although referencing OSHA workplace standards, these protections are also to be afforded to University students working or conducting research in the laboratories.

Section 9: Engineering Controls

Engineering controls include those physical accommodations within the laboratory or research facility designed to ensure and protect the health and safety of employees / students. These include the ventilation system, and the laboratory safety equipment. Routine laboratory or research safety equipment, such as fire extinguishers, fire blankets, eyewash stations, safety showers, and spill control kits are also important control devices to minimize personal harm and to prevent an accident from getting out of control.

9.1 Ventilation

Proper ventilation is essential to the safe operation of laboratories. Each laboratory must have an appropriate general ventilation system with air intakes and exhausts located so as to avoid intake of contaminated air. There must be adequate, well ventilated stockrooms and storerooms. Laboratories should be at negative pressure relative to the halls and surrounding classrooms so that contaminated air is not drawn out of the laboratory. All chemical hygiene related equipment and systems should undergo continuing appraisal and modifications when necessary. Furthermore, the work conducted and its scale must be appropriate to the physical facilities available, and especially to the quality of the ventilation.

9.2 Laboratory Safety Equipment

1. Fume Hoods

Laboratory type fume hoods are extremely important in providing adequate ventilation when working with hazardous compounds in the laboratory. They are to be present in all laboratories where hazardous chemicals are handled. The fume hoods are to be inspected periodically to insure adequate face velocities, and any necessary maintenance should be requested promptly. Reference Section 9.3 *infra* for more guidance on fume hoods.

2. Portable Chemical Shields

A Portable chemical shield should be used whenever there is the potential for a chemical explosion or glass breakage due to high pressure or vacuum inside a vessel. The experimental apparatus and entire chemical shield should be used inside a laboratory hood, if possible.

3. Fire Extinguishers

Fire extinguishers are to be available in or near each laboratory. Four general fire classes exist with a different type of fire extinguisher appropriate for use on each class. In the table below, it shows the four general classes of fire, the types of fuel present in each class, and the types of fire extinguishers that can be safely used to put the corresponding fire out.

With regard to the information in this table, there are a few cautionary notes. Water-based extinguishers are useful only for Class A fires and should not be used for extinguishing fires of any other type. Aqueous film-forming foam extinguishers (AFFF) conduct electricity and should

not be used on Class C fires. Using multipurpose dry chemical extinguishers in a confined area may produce a cloud that reduces visibility. Also, halon 1211 may be toxic if inhaled (at >4 % halon/unit air volume) and can decompose to give dangerous by products at 900°F (480°C). It is also important to note that carbon dioxide fire extinguishers may cause frostbite, and suffocation is possible if they are used in a confined area. Carbon dioxide extinguishers with a metal discharge horn will also conduct electricity and should never be used on a Class C fire. Finally, a Class ABC rated fire extinguisher should NEVER be used on a Class D fire since it may make the fire worse. Class D fires should be smothered with sand or a Class D fire extinguisher

Class	Fuel Source: Examples	Appropriate Fire Extinguisher Type
A	Ordinary Combustibles: Wood, paper, rubber, natural fibers, some plastics	Water based; Aqueous film-forming foam (AFFF); Multipurpose dry chemical; Halon 1211
B	Flammable Liquids: Flammable liquids and gases, greases, tars, oil-base paints, and other volatile liquids	Carbon dioxide; Dry chemical; Halon 1211; Multipurpose dry chemical; Film-forming foam (AFFF)
C	Electrical: Energized electrical wiring or electrical equipment	Dry chemical; Halon; Multipurpose dry chemical; Carbon dioxide without a metal discharge horn
D	Combustible Metals: Solid sodium metal or lithium metal	Specialized class D; Do NOT use an ABC type fire extinguisher

4. Fire Blankets

Fire blankets should be provided in all laboratories where flammable compounds may be used for instructional and/or research purposes.

5. Emergency Eyewash Stations

Eyewash stations should be checked weekly (See Appendix F - Eye Maintenance log sheet) to make sure that they are working properly; any required maintenance is to be performed promptly. Eyewash stations should be present or immediately available in laboratories, storerooms, or stockrooms where hazardous chemicals are handled or stored. Prominent signs should identify the presence and location of this and other safety and first aid equipment in the lab.

Emergency Safety Showers

6. Emergency Safety Showers

An easily accessible drench-type safety shower or drench hose should be present wherever hazardous chemicals are stored or used. Prominent location signs should identify the presence

and location of this and other safety and first aid equipment in the lab. The proper operation of safety showers should be checked monthly, and prompt maintenance provided if necessary.

9.3 Fume Hoods

Fume hoods provide primary confinement in a chemical laboratory. They exhaust toxic, flammable, noxious, or hazardous fumes and vapors by capturing, diluting, and removing these materials. Fume hoods also provide physical protection against fire, spills, and explosion. Fume hoods provide the best protection when the fume hood sash is in the closed position. All chemical fume hoods must be ducted to the outside of the building.

1. Types of Fume Hoods

There are three basic types of fume hoods: (1) standard, (2) bypass, and (3) auxiliary air.

- a. Standard Fume Hoods: The face velocity of a standard fume hood is inversely related to the open face area, allowing a constant volume of air to be exhausted. If the sash is lowered, the inflow air velocity increases. **IMPORTANT:** *Face velocity that is too high may disturb sensitive apparatus, extinguish Bunsen burners, or create excessive turbulence.*
- b. Bypass Fume Hoods: Bypass fume hoods are also called "balanced air" or "constant volume" fume hoods. As the sash is lowered, bypass fume hoods allow constant exhaust volumes that help keep the room ventilation system balanced. Constant exhaust volumes also eliminate the problem of high face velocity as the sash is lowered.
- c. Auxiliary Air Fume Hoods: Auxiliary air fume hoods are also known as "supplied air" hoods. They use an outside air supply for 50% to 70% of the hood's exhaust requirements. This type of hood is designed to reduce utility costs and conserve energy. The face velocity of an auxiliary air fume hood may vary.

2. Classification Types

The following guidelines are recommendations for use and face velocities for the three classes of chemical fume hoods.

- a. Class A Fume Hood: This class of hood is suitable for use with highly toxic or volatile materials having a TLV of less than 1 ppm (e.g., tetraethyl lead, beryllium compounds, metal carbonyls, and carcinogens). Recommended average face velocity is 115 to 125 fpm with a minimum of 100 fpm at any point.
- b. Class B Fume Hood: This class of hood is suitable for use with materials having a TLV of 1-100 ppm (e.g., acids, formaldehyde, chloroform, and phenol). Recommended average face velocity is 95 to 110 fpm with a minimum of 80 fpm at any point.

CHEMICAL HYGIENE PLAN

- c. Class C Fume Hood: This class of fume hood is suitable for use with materials having a TLV greater than 100 ppm (e.g., ethanol, butanol, and acetone). It is also suitable for operations that create nuisance dust and fumes. Recommended average face velocity is 75 to 95 fpm with a minimum of 60 fpm at any point.

3. Special Fume Hoods

Special fume hoods are necessary when working with certain chemicals and operations. Examples of special fume hoods include, but are not limited to, the following:

- a. Perchloric acid fume hoods: These fume hoods have a water spray system to wash down the entire length of the exhaust duct, the baffle, and the wall. The water spray is used periodically or after each use to remove any perchloric acid or organic material that may have accumulated.
- b. Walk-in hoods: These fume hoods have single vertical sashes or double vertical sashes and an opening that extends to the floor. These hoods are typically used to accommodate large pieces of equipment.
- c. Radioisotope hoods: These hoods are labeled for use with radioactive materials. The interior of these hoods is resistant to decontamination chemicals. If special filtration is necessary with these fume hoods, contact EH&S.
- d. Canopy hoods: These hoods capture upward moving contaminants and are good for heat-producing operations. Workers may be exposed to contaminants if they work under the hood, however.

4. Fume Hood Safety Considerations

The potential for glass breakage, spills, fires, and explosions is great within a fume hood. Due to the chance for fires or explosions, fume hoods should be located towards the back of a laboratory, away from primary and secondary exits. Safe work habits when working with fume hoods include, but are not limited to, the following:

- a. Ensure that there is sufficient aisle space in front of fume hoods to allow for appropriate air flow and ventilation. Employee traffic in front of fume hoods or opening/closing laboratory doors can interfere with hood performance.
- b. All fume hoods are not appropriate for all types of work. Ensure that hazardous chemicals are used in the proper type or class of hood. For example, use perchloric acid only in fume hoods specifically designed for perchloric acid.

5. Fume Hood Use and Care

To ensure safe and proper fume hood performance, follow these guidelines in the use and care of fume hoods:

CHEMICAL HYGIENE PLAN

- a. Use a fume hood when working with chemicals or procedures that may produce hazardous fumes or vapors.
- b. Know how to properly operate a fume hood before beginning work. Inspect the fume hood before starting each operation.
- c. Place equipment and chemicals at least six inches behind the fume hood sash. This practice reduces the chance of exposure to hazardous vapors.
- d. Do not allow paper or other debris to enter the exhaust duct of the hood.
- e. Do not store excess chemicals or equipment in fume hoods.
- f. Do not block the baffle area of the fume hood.
- g. Elevate any large equipment within the hood at least three inches to allow proper ventilation around the equipment.
- h. When working in a fume hood, set the sash at the height indicated by the arrow on the inspection sticker. The only time the sash should be completely open is while setting up equipment.
- i. Wear personal protective equipment, as appropriate.
- j. Do not alter/modify the fume hood or associated duct work.
- k. Clean up spills in the hood immediately.

IMPORTANT: *If a power failure or other emergency occurs (e.g., building fire or fire within the fume hood), close the fume hood sash and call immediately for emergency assistance.*

6. Fume Hood Inspections

Fume hoods should be tested at least annually. Fume hoods should also be tested in the following circumstances:

- a. When an employee requests an inspection
- b. When a procedural change requires a hood classification upgrade
- c. After major repair work
- d. After a fume hood is moved

Fume hood inspections are usually performed by outside contractors. All records are maintained by EH&S as required by regulatory agencies.

A velocity test, which is part of a fume hood inspection, is performed with a smoke test to assure that the hood has not deviated from the ASHRAE 110 Tracer Gas test conditions. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has a test called the 110 Tracer Gas test which utilizes sulfur hexafluoride to detect and measure gas leakage in parts per million (ppm) from the hood under varying conditions. This is mandated by OSHA – 29CFR 1910.1450.

9.4 Chemical Storage Cabinets

Chemical storage cabinets are used to store flammables and corrosives. All chemicals should be stored in limited quantities. The cabinets must be vented and meet OSHA 1910.106d and NFPA 30 specifications. Incompatible chemicals are to be segregated and stored in different cabinets according to compatible groups or hazard classes. The types of cabinets used for chemical storage are:

- a. Flammable liquid storage cabinets which are designed for storage of flammable or combustible liquids. (See 9.4 *supra*)
- b. Acid / corrosive storage cabinets which are designed for corrosion resistance.
- c. Bulk storage cabinets which are to be used to store flammables and corrosive liquids outside of the working area.

The NFPA and OSHA require flammable cabinets to be designed and constructed to specific requirements. 1910.106(d)(3)(ii)(a) states that metal cabinet shall be constructed in the following manner:

- Bottom, top and sides of cabinet shall be at least No. 18 ga. sheet steel
- Cabinet must be doubled walled with 1½" airspace
- Joints shall be riveted, welded or made tight by some equally effective means
- Door shall have a three-point latch
- Door sill shall be raised at least 2" above the cabinet bottom to retain spilled liquid within the cabinet
- Cabinet shall have a "FLAMMABLE—KEEP FIRE AWAY" legend

These regulations also provide an option for wood cabinets. 1910.106(d)(3)(ii)(b) states that wood cabinets shall be constructed in the following manner:

- Bottom, top and sides of cabinet shall be at constructed of exterior grade plywood at least 1" thick
- Plywood shall not break down or delaminate under fire conditions
- Joints shall be rebuted and fastened in two directions with flathead wood screws
- When more than one door is used, they should have a rebuted overlap of not less than 1"
- Doors shall be equipped with latches and hinges that are mounted to not lose their holding capacity when subjected to fire
- Door sill or pan shall be raised at least 2" above the cabinet bottom to retain spilled liquid within the cabinet
- Cabinet must have a "FLAMMABLE—KEEP FIRE AWAY" legend

Chemical Storage Cabinets are usually used for acid and corrosives but can be used as a flammable cabinet if vented. If incompatible chemicals are stored and have to be segregated then different storage cabinets are required according to the chemical class and MSDS storage requirements.

CHEMICAL HYGIENE PLAN

1. Flammable Storage Cabinets

Flammable-Liquid storage cabinets are designed for the storage of flammable liquids and must be properly used and maintained. Only compatible materials are permitted to be stored inside these cabinets. Paper, cardboard or other combustible packaging materials must not be stored in a flammable cabinet. The NFPA Guidelines and OSHA Standards on Flammable Liquids are utilized as standards (29 CFR 1910.106, NFPA 30 and NFPA 45).



2. Flammable Refrigerators

Flammable chemicals cannot be stored in a conventional refrigerator. If a cold room is used for the storage of flammables then it must be ventilated and have a fire suppression sprinkler system.

Two types of refrigerators are approved for flammable storage:

- a. A flammable materials refrigerator with no spark sources and
- b. An explosion-proof refrigerator with all spark sources completely sealed.

9.5 Personal Protective Equipment (PPE)

1. Responsible Parties

Supervisors and Principal Investigators are responsible for the PPE program in their respective laboratories and research departments. The PPE program shall include an enforcement component and a maintenance component. Appropriate disciplinary action must be taken for repeated violation of this program. Each Department must provide the necessary PPE for their employees. To assist with PPE determinations, a PPE guide to hazard sources can be found in Appendix G. If there are any questions on how to select PPE, contact EH&S.

2. Workplace Assessments

Supervisors and Principal Investigators are to conduct a workplace assessment in each laboratory to determine if hazards requiring the use of PPE are present annually or whenever the scope of

CHEMICAL HYGIENE PLAN

work has changed. This is often a complex task; therefore sample copy of a workplace assessment form can be found in Appendix H.

If potential hazards are present in the laboratory, do the following:

- a. Identify each hazard and the source
- b. Determine which body parts are affected
- c. Select appropriate PPE against the hazard
- d. Train each employee on the hazards present and when PPE should be worn
- e. Train employees on the proper use, maintenance and limitations of each PPE device used
- f. Maintain training records within the department
- g. Complete and maintain a workplace assessment form for each task or process performed in the laboratory that requires PPE

Do not rely upon PPE alone to completely protect against hazards. Rather, PPE should be used in conjunction with effective engineering controls and workplace practices to minimize hazards in the workplace.

3. Eye Protection

All safety eyewear must meet the ANSI Z87.1 standard for minimum allowable eye protection. All eye protection will be supplied by Nova Southeastern University Departments.

If the potential for liquids to be splashed or sprayed is present, wear safety goggles. However, safety glasses do not necessarily give adequate protection from chemical splashes. When liquids are under extreme, high pressure, wear a face shield. Never wear a face shield without wearing safety goggles underneath.

Some chemical eye and face protection does not afford impact protection.

Eye Protection is required:

- a. When working with or in the vicinity of solvents or corrosive chemicals, or with any chemical that could produce an eye injury
- b. When working near equipment or apparatus under high pressure or vacuum, or when around equipment that could produce projectiles
- c. When near laboratory benches where chemical reactions are being run or when around a radiation hazard
- d. When transporting flammable, corrosive or toxic chemicals
- e. During maintenance activities involving chemicals, hand/power or machine tools, welding, cutting, grinding, or abrasive blasting
- f. When working behind hood doors or blast shields

Contact lenses do not provide eye protection! Wearing contact lenses is discouraged when working with materials or procedures that give off gases, vapors, welding fumes, smoke or dust. If you choose to wear contacts, be aware of the hazards of wearing contacts in a lab.

4. Gloves

Gloves provide protection against chemical, radiological and biological agents. Selection of proper gloves for the work task is critical in maintaining protection against hazardous agents. The Chemical Safety Officer can assist employees / students in the selection of proper gloves. A glove selection table can be found in Appendix I.

The following are recommendations for safe glove usage:

- a. When working with corrosive liquids, solvents, or other potentially hazardous materials, wear proper gloves. One type of glove will not protect against all chemicals; therefore proper glove selection is critical.
- b. Remove gloves prior to answering phones, using computers, opening doors, or any other situation that might cause the spread of hazardous materials.
- c. Remove gloves prior to leaving the laboratory area.
- d. Wash hands anytime gloves are removed.
- e. Be careful not to touch other parts of your body or apparel while wearing gloves (i.e. pushing up your glasses, etc.).
- f. Dispose gloves as hazardous waste if they meet the characteristics of a hazardous waste.

5. Respiratory Protection

Respirators are designed to keep the wearer from inhaling toxic chemicals or other contaminants in the air during accidents, emergencies or when engineering controls are not sufficient to maintain exposures below the Permissible Exposure Limit (PEL). **If you plan to use a respirator, see EH&S prior to use.**

Respirators have inherent hazards, should be considered the last line of defense, and should not be used during routine laboratory operation. When required, respirators are available to employees at no cost.

Departments shall make every effort to use engineering and workplace controls to minimize exposures. Respirators shall only be used when engineering controls and workplace practices fail to reduce the exposures below the PEL. Departments are responsible for ensuring compliance.

Department responsibilities include:

- a. Inform the Chemical Safety Officer of potential health hazards that may require the use of respirators.
- b. Ensure employees receive a respirator fit test prior to respirator usage.
- c. Ensure employees have received proper medical and training clearance before they start using respirators.
- d. Ensure employees use and store the respirator in compliance with regulations.
- e. Ensure respirators are stored in a closed container, shelf, or cabinet.
- f. Ensure respirators are kept clean and dust-free, and washed, when necessary.

CHEMICAL HYGIENE PLAN

- g. Ensure respirator cartridges are changed on a regular basis according to specifications or use limitations. NOTE: Cartridges may be a hazardous waste.
- h. Require training for all employees using respirators. Make sure training is recorded and on file with EH&S.

6. Laboratory Coats

Laboratory coats are issued to prevent the spread of hazardous materials outside the laboratory. Protective clothing is also provided to prevent damage to employees' personal clothing. Protective clothing is only to be worn on site or for external activities relating to laboratory requirements where protective clothing is needed. Remove contaminated clothing before leaving the laboratory area.

7. Laboratory Attire

All employees and students are required to wear appropriate clothing when in the laboratory, storage and animal rooms for safety reasons. Shorts, short skirts, halter tops, high heels, sandals, open-toed shoes, and shoes with uppers constructed of woven material are not allowed. Tie back long hair and loose clothing and remove dangling jewelry prior to working in the laboratory.

8. Hearing Protection

If in the laboratory setting and a process is conducted with a high noise output, contact EH&S to conduct a noise survey. As a rule of thumb, if you have to raise your voice to have a conversation with the person standing next to you, then the noise may be at a level that requires a noise survey and assessment.

From this survey, the following items can be addressed:

- a. Sources of noise output;
- b. Whether the action levels are exceeded;
- c. Types of hearing protection devices needed and when they should be worn;
- d. Who is affected by the problem and whether the affected employee needs to participate in the Hearing Conservation Program

Section 10: Classification of Hazardous Substances

Working with potentially hazardous chemicals is an everyday occurrence in a laboratory setting. Hazardous situations can occur if employees are not educated in general chemical safety, toxicological information, and procedures for handling and storage for the chemicals they are using. This section of the chemical hygiene plan addresses these educational components and spells out specific protocols to minimize hazardous chemical exposures.

A chemical is a physical hazard if it is:

- A flammable or combustible liquid
- A compressed gas
- An explosive
- An organic peroxide
- An oxidizer
- A pyrophoric compound
- An unstable material (reactive)
- A water reactive substance.

A chemical is a health hazard if there is significant evidence that acute or chronic health effects from chemical exposure may occur in employees. Included are:

- carcinogens
- irritants
- reproductive toxins
- corrosives
- sensitizers
- radioactive material
- neurotoxins
- hepatotoxins
- nephrotoxins
- biohazards
- Teratogens
- hematopoietic system agents
- allergens
- embryotoxicants
- eyes or mucous membranes

In most cases, the label will indicate if the chemical is hazardous. Look for key words like caution, hazardous, toxic, dangerous, corrosive, irritant, carcinogen, etc.

10.1 Modes of Entry

There are four major modes of entry into the human system by chemicals: (1) inhalation, (2) skin absorption, (3) injection, and (4) ingestion. Inhalation and skin absorption are the predominant occupational exposures you may expect to encounter in the laboratory and will be discussed in some detail. Accidental injection of chemicals can be eliminated by good laboratory safety practices. Accidental ingestion of chemicals can be eliminated by a combination of good laboratory and hygienic practices such as washing hands and prohibiting foods, drinks, cosmetics, and tobacco products in the laboratory workplace.

All potential exposures, i.e., inhalation, skin absorption, injection, and ingestion, are discussed in the Material Safety Data Sheets (MSDSs) available for each chemical or product. The hundreds of chemicals that employees are routinely exposed to during the course of their work in the laboratory can be divided into three main types: volatile solvents, corrosives, and toxic solids.

CHEMICAL HYGIENE PLAN

The particular hazards associated with exposure to these materials, and ways to avoid them, are discussed in detail below.

10.2 Corrosives

A corrosive chemical destroys or damages living tissue by direct contact. A chemical is defined as being corrosive if it meets one of the following definitions:

- a. Fits the OSHA definition of corrosive in Appendix A of 29 CFR 1910.1200 (a chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.).
- b. Fits the EPA definition of corrosive in 40 CFR 261.22 (has pH greater than 12 or less than 2.5).
- c. Is known or found to be corrosive to living tissue.

Some acids, bases, dehydrating agents, oxidizing agents, and organics are corrosives. Acids and alkalis, for example, are known to be corrosive to living tissue. A contact-hazard chemical is an allergen or sensitizer that is so identified in the MSDS or label; is so identified in the medical or industrial hygiene literature; or is known to be an allergen or sensitizer.

Examples of acidic corrosives include, but are not limited to, the following:

- Hydrochloric acid - inorganic, mineral acid
- Phosphoric acid - inorganic, mineral acid
- Acetic acid - organic acid
- Butyric acid - organic acid

Examples of alkaline / bases corrosives include, but are not limited to, the following:

- Sodium hydroxide - inorganic base
- Potassium hydroxide - inorganic base
- Ammonia

Examples of corrosive dehydration agents include, but are not limited to, the following:

- Phosphorous pentoxide
- Calcium oxide

Examples of corrosive oxidizing agents include, but are not limited to, the following:

- Halogen gases
- Perchloric acid
- Sulfuric acid - inorganic acid
- Nitric acid - inorganic acid

Examples of organic corrosives include, but are not limited to, the following:

- Phenol
- Acetic acid (Glacial)

***NOTE:** Concentrated acids can cause painful burns that are often superficial. Inorganic hydroxides, however, can cause serious damage to skin tissues because a protective protein layer does not form. Even a dilute solution such as sodium or potassium hydroxide can saponify fat and attack skin. At first, skin contact with phenol may not be painful, but the exposed area may turn white due to the severe burn. Systemic poisoning may also result from dermal exposure.*

1. Safe Handling Guidelines for Corrosives

- a. Always wear proper PPE, especially eye protection (items may include safety goggles and face shield, gloves known to be resistant to permeation or penetration, laboratory aprons, laboratory coats).
- b. Add acids and alkalis to water; never add water to acids or alkalis.
- c. Add acid to water slowly, as a great deal of heat will be formed.
- d. Use a chemical fume hood when handling fuming acids or volatile irritants (e.g., ammonium hydroxide).
- e. Provide secondary containment for storage bottles unless bottles are PVC-coated.
- f. Corrosives, especially inorganic bases (e.g., sodium hydroxide), may be very slippery; handle these chemicals with care and clean any spills, leaks, or dribbles immediately.
- g. Treat any accident resulting in contact with the skin immediately. Wash affected area with large amounts of water for at least 15 minutes. Seek immediate medical attention for chemical burns resulting from concentrated solutions.
- h. Always separate and store acids, alkalis and other corrosive materials below eye level in properly labeled storage cabinets. Refer to the MSDS's and Section 11 (Chemical Storage) of this Plan for more information.
- i. Store acids away from cyanides.
- j. Store acids and bases away from flammable liquids and solvents.
- k. Inspect containers frequently for corrosion.
- l. Make an effort to minimize quantities according to your application.
- m. A continuous flow eye wash station should be in every work area where corrosives are present.
- n. An emergency shower should also be within 100 feet of the area.

2. A Note on Perchloric Acid

Perchloric acid is a strong oxidizing agent and a strong dehydrating reagent that can be dangerously reactive. Perchloric acid reacts violently with organic materials. When combined with combustible material, heated perchloric acid may cause a fire or explosion. Perchloric acid at ordinary temperatures and concentrations of 70% or weaker, reacts as a strong, non-oxidizing acid. At concentrations above 70% or at elevated temperatures (usually above 160 degrees Celsius), Perchloric acid is an exceedingly strong, active oxidizer and a dehydrating agent. Anhydrous perchloric acid is unstable at room temperature and will ultimately decompose spontaneously with violent explosion.

At elevated temperatures perchloric acid is not a very strong oxidizer, but its oxidizing strength increases significantly at concentrations higher than 70%. Anhydrous perchloric acid (>85%) is very unstable and can decompose spontaneously and violently.

If possible, purchase 60% perchloric acid instead of a more concentrated grade. Always wear gloves and goggles while using perchloric acid. Be thoroughly familiar with the special hazards associated with perchloric acid before using it.

Heated digestions with perchloric acid require a special fume hood with a wash-down system.

10.3 Flammable Chemicals

A flammable chemical is any solid, liquid, vapor, or gas that ignites easily and burns rapidly in air. Consult the appropriate MSDSs before beginning work with flammables.

1. Flashpoint, Boiling Point, Ignition Temperature, and Class

Flammable chemicals are classified according to flashpoint, boiling point, and ignition temperature. Flashpoint (FP) is the lowest temperature at which a flammable liquid gives off sufficient vapor to ignite. Boiling point (BP) is the temperature at which the vapor pressure of a liquid vaporizes. Flammable liquids with low BPs generally present special fire hazards. The FPs and BPs of certain chemicals are closely linked to their ignition temperature—the lowest temperature at which a chemical will ignite and burn independently of its heat source.

The following table illustrates flammable and combustible liquids class characteristics:

Table B: Flammable and Combustible Liquids Class Characteristics

CLASS	FLASHPOINT	BOILING POINT	EXAMPLES
1A	<73°F (22.8 °C)	< 100 °F (37.8 °C)	Ethyl ether "Flammable" aerosols
1B	< 73 °F (22.8 °C)	≥ 100 °F (37.8 °C)	Acetone Gasoline, Ethanol Benzene
1C	≥ 73 °F (22.8 °C) < 100 °F (37.8°C)		Butyl alcohol, Xylene Turpentine
2	≥ 100 °F (37.8 °C) < 140 °F (60 °C)		Cyclohexane Kerosene Mineral spirits
3A	≥ 140 °F (60 °C) < 200 °F (93 °C)		Aniline Glycerine
3B	≥ 200 °F (93 °C)		Ethylene glycol Chloroform

CHEMICAL HYGIENE PLAN

2. Conditions for a Fire

Improper use of flammable liquids can cause a fire. The following conditions must exist for a fire to occur:

- a. Flammable material must be present in sufficient concentration to support a fire (i.e., fuel).
- b. Oxygen or another oxidizer must be present.
- c. An ignition source must be present (i.e., heat, spark, etc.).

When working with flammables, always take care to minimize vapors which act as fuel.

3. Safe Handling Guidelines for Flammable Chemicals

Follow these guidelines when working with flammable chemicals:

- a. Handle flammable chemicals in areas free from ignition sources.
- b. Never heat flammable chemicals with an open flame. Use a water bath, oil bath, heating mantle, hot air bath, etc.
- c. Use ground straps when transferring flammable chemicals between metal containers to avoid generating static sparks.
- d. Use a fume hood when there is a possibility of dangerous vapors. (Ventilation will help reduce dangerous vapor concentrations.)
- e. Restrict the amount of stored flammables, and minimize the amount of flammables present in a work area.
- f. Remove from storage only the amount of chemical needed for a particular experiment or task.

4. Solvents

Organic solvents are often the most hazardous chemicals in the work place. Solvents such as ether, alcohols, and toluene, for example, are highly volatile or flammable. Chlorinated solvents such as chloroform are nonflammable, but when exposed to heat or flame, may produce carbon monoxide, chlorine, phosgene, or other highly toxic gases.

Always use volatile and flammable solvents in an area with good ventilation or in a fume hood. Never use ether or other highly flammable solvents in a room with open flames or other ignition sources present.

a. Solvent Exposure Hazards

Health hazards associated with solvents include exposure by the following routes:

Inhalation: Inhalation of a solvent may cause bronchial irritation, dizziness, central nervous system depression, nausea, headache, coma, or death. Prolonged exposure to excessive

CHEMICAL HYGIENE PLAN

concentrations of solvent vapors may cause liver or kidney damage. The consumption of alcoholic beverages can enhance these effects.

Skin Contact: Skin contact with solvents may lead to defatting, drying, and skin irritation.

Ingestion: Ingestion of a solvent may cause severe toxicological effects. Seek medical attention immediately.

In addition, some solvents (e.g., benzene) are known or suspected carcinogens.

The odor threshold for the following chemicals exceeds acceptable exposure limits. Therefore, if you can smell it, you may be overexposed---increase ventilation immediately.

- Chloroform
- Benzene
- Carbon tetrachloride
- Methylene chloride

While odor is a useful tool in assessing solvent exposure hazards, do not depend on your sense of smell alone to know when hazardous vapors are present. The odor of some chemicals is so strong that they can be detected at levels far below hazardous concentrations (e.g., xylene).

3 Reducing Solvent Exposure

To decrease the effect of solvent exposure, substitute hazardous solvents with less toxic or hazardous solvents whenever possible. For example, use hexane instead of diethyl ether, benzene or a chlorinated solvent. The following table outlines some possible solvent substitutions:

Table C: Solvent Substitutions

INSTEAD OF USING	SUBSTITUTE
Benzene	Cyclohexane Toluene Xylene
Halogenated solvents	Nonhalogenated solvents
Aromatic hydrocarbon	Aliphatic hydrocarbon
Trichloroethylene	1,1,1-trichloroethane
Diethyl ether	Hexane Petroleum ether

The best all-around solvent is water; use whenever possible.

b. A Note on DMSO

Dimethyl sulfoxide is a unique solvent because it is a good solvent with many water-soluble as well as lipid-soluble solutes. Due to these properties, dimethyl sulfoxide is rapidly absorbed and distributed throughout the body. It can also facilitate absorption of other chemicals such as grease, oils, cosmetics, and other chemicals that may contact the skin.

10.4 Toxic Chemicals

The toxicity of a chemical refers to its ability to damage an organ system (kidneys, liver), disrupt a biochemical process (e.g., the blood-forming process) or disturb an enzyme system at some site remote from the site of contact. Toxicity is a property of each chemical that is determined by molecular structure. Any substance can be harmful to living things. But, just as there are degrees of being harmful, there are also degrees of being safe. The biological effects (beneficial, indifferent or toxic) of all chemicals are dependent on a number of factors.

For every chemical, there are conditions in which it can cause harm and, conversely, for every chemical, there are conditions in which it does not. A complex relationship exists between a biologically active chemical and the effect it produces that involves consideration of dose (the amount of a substance to which one is exposed), time (how often, and for how long during a specific time, the exposure occurs), the route of exposure (inhalation, ingestion, absorption through skin or eyes), and many other factors such as gender, reproductive status, age, general health and nutrition, lifestyle factors, previous sensitization, genetic disposition, and exposure to other chemicals.

The most important factor is the dose-time relationship. The dose-time relationship forms the basis for distinguishing between two types of toxicity: acute toxicity and chronic toxicity. The acute toxicity of a chemical refers to its ability to inflict systemic damage as a result (in most cases) of a one-time exposure to relative large amounts of the chemical. In most cases, the exposure is sudden and results in an emergency situation.

The recommended exposure limits or OSHA-mandated limits can be found in the MSDS for most of the chemicals used in the laboratory. These limits are expressed as threshold limit values (TLV), permissible exposure limits (PEL), short term exposure limits (STEL), ceilings (C), and action levels. These limits help to serve as guidelines for determining the appropriate safety precautions to be taken when handling specific chemicals.

Eye protection, long sleeves, and gloves known to resist permeation by chemicals are to be used when handling toxic chemicals. Further, chemicals must be used in an operating fume hood, glove box, vacuum line, or a similar device which is equipped with appropriate traps and/or scrubbers under the following conditions:

- a. When a TLV or PEL value is less than 50 ppm or 100 mg/m³.
- b. When the animal or human median inhalation lethal concentration, LC₅₀, is less than 200 ppm or 2000 mg/m³ when administered continuously for one hour or less (this

- condition is followed in the event that a TLV, PEL, or comparable value is not available for that chemical).
- c. When laboratory handling of a chemical with a moderate or greater vapor pressure will be likely to exceed air concentration limits

If this equipment is not available, then no work shall be performed using that chemical.

Chronic toxicity refers to a chemical's ability to inflict systemic damage as a result of repeated exposures, over a prolonged time period, to relatively low levels of the chemical. Some chemicals are extremely toxic and are known primarily as acute toxins (hydrogen cyanide); some are known primarily as chronic toxins (lead). Other chemicals, such as some of the chlorinated solvents, can cause either acute or chronic effects.

The toxic effects of chemicals can range from mild and reversible (e.g., a headache from a single episode of inhaling the vapors of petroleum naphtha that disappears when the victim gets fresh air) to serious and irreversible (liver or kidney damage from excessive exposures to chlorinated solvents). The toxic effects from chemical exposure depend on the severity of the exposures. Greater exposure and repeated exposure generally lead to more severe effects.

Exposure to toxic chemicals can occur by: (1) inhalation; (2) dermal absorption; (3) ingestion; and (4) injection. Inhalation and dermal absorption are the most common methods of chemical exposure in the workplace.

The following sections provide examples and safe handling guidelines for toxicants, carcinogens, reproductive toxins, sensitizers, and irritants.

10.4 Toxicants

A toxicant (or toxic) is a chemical compound that has an effect on organisms. Toxicants are typically introduced into the environment by human activity. Many toxicants are pesticides, or are unwanted by-products of some production process, or accidental spoils.

1. Acute Toxins

Acute toxins can cause severe injury or death as a result of short-term, high-level exposure. Examples of acute toxins include, but are not limited to, the following:

- a. Hydrogen cyanide
- b. Hydrogen sulfide
- c. Nitrogen dioxide
- d. Ricin
- e. Organophosphate pesticides
- f. Arsenic

Do not work alone when handling acute toxins. Use a fume hood to ensure proper ventilation.

2. Chronic Toxins

Chronic toxins can cause severe injury after repeated exposure. Examples of chronic toxins include, but are not limited to, the following:

- a. Mercury
- b. Lead
- c. Formaldehyde

3. Safe Handling for Acute and Chronic Toxins:

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

Use these chemicals in a chemical fume hood or other appropriate containment device if the material is volatile or the procedure may generate aerosols. If a chemical fume hood is used, it should be evaluated to confirm that it is performing adequately.

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

Decontaminate working surfaces with wet paper towels after completing procedures. Place the towels in plastic bags and secure. Volatile chemicals should be transported between laboratories in durable outer containers.

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

If one or more of these substances are used in large quantities, on a regular basis (three or more separate handling sessions per week), or for long periods of time (4-6 hours) a qualitative and potentially quantitative exposure assessment should be performed. Lab personnel of childbearing age should be informed of any known male and female reproductive toxins used in the laboratory. An employee who is pregnant, or planning to become pregnant, and who is working with potential reproductive toxins that might affect the fetus, should contact the Environmental Health and Safety Department to evaluate their exposure and inform her personal physician.

10.5 Carcinogens

Carcinogens are materials that can cause cancer in humans or animals. Several agencies including OSHA, NIOSH, and IARC are responsible for identifying carcinogens. There are very few chemicals known to cause cancer in humans, but there are many suspected carcinogens and many substances with properties similar to known carcinogens.

Examples of known carcinogens include, but are not limited to, the following:

- a. Asbestos

CHEMICAL HYGIENE PLAN

- b. Benzene
- c. Tobacco smoke
- d. Chromium, hexavalent
- e. Aflatoxins

Zero exposure should be the goal when working with known or suspected carcinogens. Workers who are routinely exposed to carcinogens should undergo periodic medical examinations. See Appendix M for a list of select carcinogens. What about safe handling of carcinogens?

10.6 Reproductive Toxins

Reproductive toxins are chemicals that can produce adverse effects in parents and developing embryos. Chemicals including heavy metals, some aromatic solvents (benzene, toluene, xylenes, etc.), and some therapeutic drugs are capable of causing these effects. In addition, the adverse reproductive potential of ionizing radiation and certain lifestyle factors, including excessive alcohol consumption, cigarette smoking, and the use of illicit drugs, are recognized.

While some factors are known to affect human reproduction, knowledge in this field (especially related to the male) is not as broadly developed as other areas of toxicology. In addition, the developing embryo is most vulnerable during the time before the mother knows she is pregnant. Therefore, it is prudent for all persons with reproductive potential to minimize chemical exposure. What about examples and safe handling of reproductive toxins?

Safe handling of Carcinogens and Toxins

This section outlines the recommendations for general safeguards that should be observed when working with chemical carcinogens and toxins in the laboratory. These safeguards will provide protection to the laboratory worker/student from exposure to chemical carcinogens or toxins in the majority of situations.

1. Personnel Practices

PPE. Laboratory clothing that protects street clothing, such as a fully fastened laboratory coat, should be worn when chemical carcinogens and toxins are being used. Laboratory clothing should not be worn outside the laboratory area. Clothing overtly contaminated by chemical carcinogens/toxins should be removed immediately and disposed of or decontaminated prior to laundering. Gloves which are appropriate to the task and chemicals in use should be worn when handling a chemical carcinogen and toxins. Disposable gloves should be discarded after each use and immediately after overt visible contact with a chemical carcinogen or toxin.

Eye Protection. Devices to provide appropriate eye protection should be available and used in the laboratory work area. The type of device used will depend upon the hazard presented by the operation and chemical in use.

Eating, Drinking and Smoking. There should be no eating, drinking, smoking, chewing of gum or tobacco, application of cosmetics or storage of utensils, food or food containers in laboratory areas where chemical carcinogens and toxins are used or stored.

Pipetting. Mechanical pipetting aids should always be used for all pipetting procedures.

CHEMICAL HYGIENE PLAN

Personal Hygiene. All employees and students should wash their hands immediately after completing any procedure which contained a chemical carcinogen/toxin and when leaving the laboratory. Immediately following any contact with a carcinogen or toxin, personnel should wash, or if appropriate, shower the affected area.

2. Operational Practices

The work area needs to be identification and each entrance where chemical carcinogens and toxins are being used or stored, should have affixed to it a sign with the following warning:

CAUTION
Designated Use Area.
Select Carcinogens, Reproductive Hazards, or
Substances of High Acute Toxicity may be present.
Authorized Personnel Only.

Work areas where chemical carcinogens or toxins are being used require access control and may be entered only by persons authorized by the principal investigator or his / her designee. Maintenance, custodial and emergency personnel should be advised of the hazards that they may encounter before they are called on to enter the laboratory. Access doors to work areas should be kept closed while experiments involving chemical carcinogens or toxins are in progress.

Work Surfaces on which chemical carcinogens or toxins are used should be covered with stainless steel or plastic trays, dry absorbent plastic backed paper, or other impervious material. The protective surfaces should be decontaminated or disposed of after the procedure involving a chemical carcinogen or toxin has been completed.

Primary Containment Equipment. Procedures involving volatile chemical carcinogens or toxins and solid/liquid chemical carcinogens or toxins that may result in the generation of aerosols should not be conducted on the open bench but in a chemical fume hood, or a glove box. Examples of aerosol producing procedures are: Sonication; the opening of closed vessels; transfer operations; blending; open vessel centrifugation; and the application, injection or intubation of a chemical carcinogen or toxin into experimental animals. Tissue culture and other biological procedures involving chemical carcinogens may be conducted in a Class II type B Biological Safety Cabinet.

Analytical Instrumentation which produces vapors or aerosols when used with chemical carcinogens or toxins should be captured through local exhaust ventilation at the site of their production or be vented into a chemical fume hood. When a sample containing a chemical carcinogen or toxins is removed from an analytical instrument, it should be placed in a tightly stoppered sample tube or otherwise safeguarded from contaminating the laboratory. Analytical equipment that becomes overtly contaminated should not be used until it has been decontaminated.

Storage and Inventory. Stock quantities of chemical carcinogens and/ or toxins should be stored in a designated storage area or cabinet and should be located within the laboratory work area. The storage area or cabinet should have affixed to it a sign with the following warning:

CAUTION - POTENTIAL HAZARD (define hazards)

The person responsible for the storage area should maintain an inventory of stock quantities of chemical carcinogens or toxins and the inventory should include the quantities of chemical carcinogens or toxins acquired and the dates of acquisition. Storage vessels/containers should be labeled with the following warning:

CAUTION - POTENTIAL HAZARD (define hazards)

CHEMICAL HYGIENE PLAN

Working quantities of chemical carcinogens or toxins present in the work area should be kept to a minimum.

Transportation of chemical carcinogens or toxins from one site to another (e.g., storage area to work area) should first be placed in a durable outer container. Contaminated materials which are to be transferred from work areas to disposal areas should be placed in a closed plastic bag or other suitable impermeable and sealed primary container. The primary container should be placed in a durable outer container before being transported. The outer container should be labeled with both the name of the chemical carcinogen or toxin and the following warning:

CAUTION - POTENTIAL HAZARD (define hazard)

General housekeeping procedures which suppress the formation of aerosols such as the use of a wet mop or a vacuum cleaner equipped with a high efficiency particulate air (HEPA filter) to remove particulates should be used. Dry sweeping and mopping should not be used because of the hazard of aerosol formation. In those instances where a chemical carcinogen or contaminated material is spilled, special cleanup procedures developed for the individual compound should be employed.

Vacuum Lines should be protected (e.g., with an absorbent or liquid trap and a HEPA filter) to prevent entry of any chemical carcinogen into the system. When using a volatile carcinogen or toxin, a separate vacuum pump should be used. This device should be placed within or vented into an appropriate laboratory-type hood.

Packaging and Shipping. Chemical carcinogens or toxins should be securely packaged to withstand shocks, pressure changes, and any other conditions which might cause the leakage of contents incident to ordinary handling during transportation. Information concerning the proper methods for packaging and shipping of hazardous materials is detailed in Department of Transportation regulations 49 CFR Parts 170-178. Material Safety Data Sheets (MSDS must accompany chemicals that are shipped from laboratories).

Decontamination. Contaminated materials should either be decontaminated by approved procedures that decompose the chemical to produce a safe product or be removed for subsequent disposal.

Disposal. Prior to the start of any laboratory activity involving a chemical carcinogen or toxin, plans for the handling and ultimate disposal of contaminated wastes and surplus amounts of the carcinogen should be completed. The principal investigator should obtain guidance from the Department of Environmental Health and Safety in selecting the best methods available that are in compliance with Federal, State and local regulations.

10.7 Sensitizers

Sensitizers may cause little or no reaction upon first exposure. Repeated exposures may result in severe allergic reactions. Examples of sensitizers include, but are not limited to, the following:

- a. Isocyanates
- b. Nickel salts
- c. Beryllium compounds
- d. Formaldehyde
- e. Diazomethane

What about safe handling of sensitizers?

10.8 Irritants

Irritants cause reversible inflammation or irritation to the eyes, respiratory tract, skin, and mucous membranes. Irritants cause inflammation through long-term exposure or high concentration exposure. For the purpose of this section, irritants do not include corrosives.

Examples of irritants include, but are not limited to, the following:

- a. Ammonia
- b. Formaldehyde
- c. Halogens
- d. Sulfur dioxide
- e. Poison ivy
- f. Phosgene

What about safe handling of irritants?

10.9 Reactives and Explosives

Reactive chemicals are sensitive to either friction or shock or they react in the presence of air, water, light, or heat. Explosive chemicals decompose or burn very rapidly when subjected to shock or ignition. Reactive and explosive chemicals produce large amounts of heat and gas; they are extremely dangerous.

Examples of reactive compounds include the following:

REACTIVE CLASSIFICATION	CHEMICAL EXAMPLES
Acetylenic compounds	Acetylene, Copper(1) acetylide
Azides	Benzenesulfonyl azide, Lead(11) azide
Azo compounds	Azomethane, Diazomethane
Chloro/perchloro compounds	Lead perchlorate, Potassium chlorite Silver chlorate
Fulminates	Copper(11) fulminate, Silver fulminate
Nitro compounds	Nitromethane, Trinitrotoluene
Nitrogen-containing compounds	Silver amide, Silver nitride
Organic peroxide formers	Diethyl ether, Isopropyl ether
Picrates	Picric acid (dry), Lead picrate
Peroxides	Diacetyl peroxide, Zinc peroxide
Strained ring compounds	Benzvalene, Prismane
Polymerizable compounds	Butadiene, Vinyl chloride

Should a section discussing safe handling measures be added to be consistent?

10.10 Cleaning Agents

Many of the chemicals contained in cleaning agents are corrosive. Follow these guidelines when working with any cleaning agent:

- a. Always read and understand the label instructions or the MSDS before using any cleaning agent.
- b. Mix solutions to the recommended strength.
- c. When diluting acid with water, always add the acid to the water, not the water to the acid. (Concentrated acids may splatter when mixed improperly.)
- d. Wear appropriate eye protection and gloves for the job (e.g., neoprene, nitrile, or rubber).
- e. Do not leave aerosol cans in direct sunlight or areas where the temperature may exceed 120°F. Heated aerosol cans may explode.

The following table outlines common cleaning agents, their hazards, and safety precautions.

Table D: Common Cleaning Agents/Hazards/Precautions

CLEANING AGENT	POSSIBLE HAZARDS	SAFETY MEASURES
Ammonia	<ul style="list-style-type: none"> • Can cause severe eye and lung irritation. • If mixed with bleach, can form poisonous chlorine gas. 	<ul style="list-style-type: none"> • Use in a well ventilated area. • Do not mix with bleach. • Wear eye protection.
Bleach	<ul style="list-style-type: none"> • Can produce a poisonous gas if mixed with other cleaners. 	<ul style="list-style-type: none"> • Never mix with toilet cleaners or ammonia. • Wear gloves and eye protection.
Toilet/Drain Cleaners & Lye	<ul style="list-style-type: none"> • Can cause serious burns. 	<ul style="list-style-type: none"> • Wear gloves and avoid skin contact. • Never mix with bleach. • Protect eyes from possible splashes.
Cleaning Fluids/Degreasers	<ul style="list-style-type: none"> • May cause skin and eye irritations. • May contain solvents that can cause headaches, painful cough, dizziness, and liver or kidney damage. 	<ul style="list-style-type: none"> • Avoid direct contact. • Only use in well-ventilated areas. • Follow label directions carefully.
Aerosol Sprays	<ul style="list-style-type: none"> • Can irritate nasal passages if inhaled. • Can cause eye irritation. 	<ul style="list-style-type: none"> • Follow label directions carefully. • Use in well-ventilated area.

CHEMICAL HYGIENE PLAN

Floor Waxes &
Furniture Polish

- Can irritate skin and nasal passages.

- Use in well-ventilated area.
- Avoid skin contact.

Section 11: Chemical Handling, Labeling and Storage

All laboratory work and the transfer of hazardous chemicals are to be performed in a "designated area" such as a chemical fume hood, or a portion of the laboratory so designated. The usage and storage of these chemicals must be in areas with restricted access with posted warning signs. Appropriate Personal Protective Equipment is to be worn at all times when working with hazardous chemicals. For protection and to avoid skin or eye contact from these chemicals, proper face shields, chemical resistant gloves, long sleeve gowns and other protective apparel must be used. Always wash hands immediately after working with these hazardous chemicals.



Accidents and spills of chemicals do happen so be prepared and always have at least two people present at all times, especially if the compound is highly toxic or of unknown toxicity. Use a chemically resistant tray to store breakable containers. If a spill occurs outside the chemical fume hood; the spill procedure is to be followed and for a major spill the area has to be evacuated.

11.1 General Chemical Handling Guidelines

The following guidelines are applicable to nearly all uses of chemicals in laboratories. They apply to most hazardous chemicals, such as acids, bases, and flammable liquids. They are also applicable to chemicals that display low carcinogenic potency in animals and are not considered carcinogens.

The general guidelines are not, by themselves, adequate for chemicals with high acute toxicity or high chronic toxicity such as heavy metals, chemical carcinogens, or reproductive toxins.

- a. Know the hazards involved with all chemicals you will be working with before starting work in the laboratory and consult the MSDS before you use a chemical
- b. Wear eye protection at all times where chemicals are used or stored. Splash goggles are required whenever a splash hazard exist. Safety glasses are only suitable in situations where physical hazards exist.
- c. Wear a lab coat or other protective clothing (e.g., aprons). Heavy duty aprons are available when using concentrated acids and bases. Lab coats and gloves are worn only in the lab. They are not taken outside the lab to lunch rooms or offices nor are they worn outdoors. Lab coats shall be cleaned frequently.
- d. Gloves are chemical specific. Gloves suitable for one chemical may not be adequate in protecting against another. When working with a highly toxic substance, be sure you are using the proper gloves. Inspect them before use. Wash reusable gloves before removal. Turn disposable gloves inside out carefully when removing to avoid contaminating hands.
- e. Wash hands immediately after removing gloves, after handling chemical agents, and before leaving the lab, even though you wore gloves.
- f. Confine long hair and loose clothing.

CHEMICAL HYGIENE PLAN

- g. Closed-toe shoes, preferably leather, that cover the entire foot are required for everyone entering a lab.
- h. Do not store or prepare food, eat, drink, chew gum, apply lip balm or cosmetics, or handle contact lenses in areas where hazardous chemicals are present.
- i. Never pipette or start a siphon by mouth.
- j. Know the location of and how to use the emergency equipment in the lab in which you are working.
- k. Use caution when transporting chemicals:
 - i. Transport chemicals on a cart that can contain a spill or inside a secondary container that is sealed.
 - ii. Use a non-breakable, secured secondary container for transporting a hazardous chemical that exceeds 1 liter or 1 kg.
- l. Avoid unnecessary exposure to chemicals by any route (inhalation, absorption, ingestion or injection).
- m. Never smell or taste chemicals. Again, label containers properly to avoid confusion about contents.
- n. All persons, including visitors should wear proper personal protection, wherever chemicals are stored or used.
- o. Avoid hazards to the environment by following accepted waste disposal procedures.
- p. All chemicals must be correctly and clearly labeled.
- q. Chemicals are not stored merely by alphabetical order but segregated according to class.
- r. Keep work areas clean and uncluttered.
- s. Keep personal belongings away from chemicals.
- t. Know the emergency procedures for the building, the department, and the chemicals being used.
- u. Vent into local exhaust devices any apparatus that may discharge toxic vapors, fumes, mists, dusts, or gases. Never release toxic chemicals into cold rooms or warm rooms that have recirculating atmospheres.
- v. Use chemical fume hoods or other engineering controls to minimize exposure to airborne contaminants.

11.2 General Chemical Labeling Guidelines

Proper chemical labeling is essential for a safe laboratory work environment. The absence of labels or use of abbreviations, formulas, or chemical structures on labels can lead to accidental exposure to chemicals whose labels have been misinterpreted and to the production of unknown chemical wastes.

"Unlabeled chemicals" not only present potential hazards but are expensive to dispose.

The following are classified as "unlabeled chemicals":

- bottles without a label,
- containers labeled with only codes,
- generic process labels that do not specifically list chemicals contained,
- obviously mislabeled chemicals such as waste bottles that still have the original product label.

CHEMICAL HYGIENE PLAN

Of particular importance is the distinction between the labeling of laboratory chemical products and the labeling of laboratory chemical waste.

1. Regulatory Basis

Labeling of chemical products used in the laboratory is regulated by the Occupational Safety and Health Administration (OSHA) whereas the labeling of chemical waste generated in the laboratory is regulated by the Environmental Protection Agency (EPA). Both of these agencies define the minimum standards by which an employer or generator of hazardous waste must comply. State and local regulations may exceed these minimum requirements.

2. Labeling of Laboratory Waste

The EPA requires that containers of hazardous chemical waste be labeled according to 40 CFR 262.34(c)(1)(ii). This standard requires the containers to be labeled with the words “Hazardous Waste” or “with other words that identify the contents of the containers.”

Identifying the contents means listing the constituents of the waste including the percent water and other chemicals or components present in the waste.

3. Labeling of Laboratory Chemicals

Under the Laboratory Safety Standard labels on incoming containers of hazardous chemical must not be removed or defaced. Under the hazard communication standard all containers of hazardous materials must be labeled, tagged, or marked with the “identity” of the chemical and the appropriate hazard warning.

The “identity” is defined in OSHA’s Hazard Communication Standard as the chemical or common name that can be found on the MSDS sheet. Also in this standard, labels are not required for chemicals that are transferred to containers intended for “immediate use” and are “under the control of and used only by the person who transferred it and only within the work shift in which it was transferred.” These containers may include experimental apparatus such as beakers, flasks, and syringes; however, they must be labeled if they contain chemicals beyond the end of the shift.

Chemical labeling requirements apply to all chemical containers, hazardous and nonhazardous, (including waste containers, product containers, and secondary containers) and must be labeled with the identity (chemical name, trade name, or abbreviation found on the MSDS) and the hazardous property (corrosive, flammable, etc.). This can be accomplished by writing on the bottle with a permanent marker, affixing a hand written or typed adhesive label, string tag, or other type label to the container.

a. Labeling Basics

- i. For containers labeled by the manufacturer:
 - Inspect the labeling on incoming containers to ensure that they have legible labels.

CHEMICAL HYGIENE PLAN

- Replace damaged or semi-attached labels.
 - Manufacturer chemical labels should never be removed or defaced until the chemical is completely used.
- ii. For transferred products or prepared solutions labeled by the user:
- Label each chemical container with the chemical name and hazard warning.
 - Refer to the Material safety Data Sheet (MSDS) for hazard warning
 - Empty containers that are saved for re-use must have the original label removed or marked out and obliterated. Empty containers that are used for waste or chemical products must have a new label affixed or have the information written directly on the bottle.
 - Label all containers in English to identify the contents with the full chemical name(s) and appropriate hazard warning information. The identity on the label should correspond to a chemical name, trade name, or abbreviation found on the MSDS. No abbreviations, formulas, or chemical structures may be used unless it is otherwise labeled appropriately.
 - Unattended beakers, flasks, and other laboratory equipment containing chemicals used during an experiment should be labeled as described above. Beakers, flasks, syringes prepared and used immediately or by the end of the shift may be unlabeled.
 - Secondary containers must be labeled with the chemical name and hazard when the substance is transferred from the labeled primary container to a secondary container.
 - Synthesized chemicals must be labeled as accurately as possible until the chemical name is known, either with the chemical group or hazard class.
 - If a chemical or mixture in the lab is unknown then it is assumed to be hazardous.
 - All chemical storage areas such as cabinets, shelves and refrigerators should be labeled to identify the hazardous nature of the chemicals stored within the area (e.g., flammables, corrosives, oxidizers, water reactives, toxics, carcinogens, reproductive toxins, and general storage (non-reactive, non-hazardous). All signs should be legible and conspicuously placed.

b. Method for Labeling Small Containers

i. Legend Method:

- Label containers with abbreviated chemical name and a hazard warning.
- Provide a key in a visible location in the lab with complete chemical name.
- Document that employees are trained on the labeling system.

ii. Box or Tray Method:

- Put containers in box or tray.
- Label tray with chemical name and hazard warning
- If containers are removed from the box/tray they must be properly labeled or returned to the box or tray within the work-shift.
- Document that employees are trained on the labeling system

11.3 General Storage Requirements and Inventory Control

1. Facilities Requirements

- a. Shelves should be made of a chemically resistant material wherever flammable or corrosive chemicals are stored and should have a lip or side rails.
- b. Flammable, corrosive, or particularly hazardous chemicals should not be stored any higher than 5 feet off of the ground. Large bottles should be stored no more than two feet from ground level.
- c. No smoking or flames of any kind in chemical storerooms.
- d. All storage rooms shall have continuous ventilation and must be checked if any buildup of odors is noticed.
- e. Aisles in storage rooms must not be blocked.
- f. Storerooms cannot have floor drains in order to prevent contamination of the water supply.
- g. A storeroom shall be clearly posted for the type of hazards inside.
- h. Chemical storage rooms should not be used as preparation areas unless a separate area is set up as a preparation area. This will help limit the possible contamination of a large quantity of virgin chemicals.

2. Location of Chemicals

- a. Large quantities of chemicals must be stored in the chemical storage area.
- b. Working quantities of chemicals will be stored in one of the chemistry prep areas or in the laboratory if it is a chemical that is used on a routine basis.
- c. Chemicals used for research can be stored in research labs as long as the storage of such chemicals adheres to the requirements outlined in this chemical hygiene plan.
- d. Storage of chemicals in hoods and on lab benches should be kept to a minimum and all such containers should be returned to the appropriate storage area whenever the experiment is complete.

3. Chemical Storage

- a. Chemicals shall be segregated by hazard classification and compatibility.
- b. Storage Compatibility:
 - Inorganic acids
 - Caustics
 - Inorganics
 - Oxidizers
 - Water Reactive
 - Toxic - carcinogens, reproductive hazards
 - Flammable
 - Organic Peroxides
- c. Keep chemicals away from heaters and sunlight.
- d. Annual inspections of all containers for seal, label integrity, warning labels, quantity on hand, and any signs of decomposition.

CHEMICAL HYGIENE PLAN

- e. Labels on stored chemicals should be able to be read easily.

4. Storage of Chemicals in Laboratory Areas

- a. Chemical inventories should be kept to a minimum in working laboratories.
- b. All flammable chemicals in laboratories must be stored in a flammable cabinet.
- c. Acids should be stored in acid cabinets.
- d. Other corrosives should be stored on containment trays.
- e. Chemicals should be segregated by chemical characteristics to avoid incompatibilities.

5. Storage of Chemicals in Refrigerators

- a. All refrigerators used for the storage of potentially explosive materials must be explosion proof.
- b. Nonflammable materials can be stored in a non-explosion proof refrigerator, but cannot also be used for consumable food storage.
- c. Clearly label all materials placed in refrigerators.
- d. All refrigerators must be labeled to indicate its general use, such as "Chemical Storage Only. Do Not Store Food In This Refrigerator" or as "Food storage: No Chemicals".

6. Inventory Control

- a. An inventory of all chemicals must be maintained.
- b. An inventory of all chemicals will be conducted once a year, which will include all chemicals in prep areas, laboratories, and refrigerators.
- c. Keep the reserve supply of chemicals to a minimum.
- d. Many chemicals are assigned an expiration date. The expiration date should be strictly observed. Expired chemicals should be marked for disposal.
- e. A date received/date opened label should be placed on all chemicals when received. Whoever opens the chemical is responsible for recording the date opened.
- f. Stored chemicals must be visually inspected annually. Indications that a chemical should be disposed of include:
 - Chemical is kept passed its expiration date
 - Slightly cloudy liquids
 - Chemicals that are changing colors
 - Spotting on solids
 - Caking of anhydrous materials
 - Existence of solids in liquids or liquids in solids
 - Pressure buildup in bottles
 - Evidence of reaction with water
 - Damage to the container
 - Questionable labels
 - Leaks
 - Corroded lids

11.4 Flammable Chemicals

1. Labeling and Information

Each flammable container must be properly labeled. A proper label includes the sign of the flame. Flammable information can be found in the MSDS under Fire and Explosion Data.

2. Storage

Flammable materials are to be stored away from acids (see Appendix N). Storage areas must be cool and adequately ventilated; to prevent vapor build up and vapors mixing with the air and igniting.

Flammable chemicals are not to be stored in conventional (non-explosion proof) refrigerators. Electrical switches, lights and thermostats within refrigerators may generate sparks which can cause dangerous explosion hazards.

For storage purposes - no more than 60 gallons of a Class I flammable liquids (flash point below 100°F) or Class II combustible liquids (flash point between 100 to 140°F) and no more than 120 gallons of Class III combustible liquids (flash point between 140°F and 200°F) may be stored in an approved flammable-liquids storage cabinet.

All storage and work areas must have spill cleanup kits available and proper firefighting equipment nearby. Portable fire extinguishers must be of the class suitable for dry chemicals, foam, or carbon dioxide extinguishers. NO SMOKING is allowed in storage areas. These areas should be inspected periodically.

3. Safe Handling Guidelines for Flammable Chemicals

Follow these guidelines when working with flammable chemicals:

- a. Handle flammable chemicals in areas free from ignition sources.
- b. Never heat flammable chemicals with an open flame. Use a water bath, oil bath, heating mantle, hot air bath, etc.
- c. Use ground straps when transferring flammable chemicals between metal containers to avoid generating static sparks.
- d. Use a fume hood when there is a possibility of dangerous vapors. (Ventilation will help reduce dangerous vapor concentrations.)
- e. Restrict the amount of stored flammables, and minimize the amount of flammables present in a work area.
- f. Remove from storage only the amount of chemical needed for a particular experiment or task.
- g. Use gloves and safety goggles when handling flammable liquids or vapors and work in a fume hood. Never put flammable liquids in a microwave oven.

CHEMICAL HYGIENE PLAN

- h. When working with flammable liquids, all ignitable sources must be removed. NO SMOKING is allowed when handling flammable chemicals.

4. Solvents

Organic solvents are often the most hazardous chemicals in the work place. Solvents such as ether, alcohols, and toluene, for example, are highly volatile or flammable. Chlorinated solvents such as chloroform are nonflammable, but when exposed to heat or flame, may produce carbon monoxide, chlorine, phosgene, or other highly toxic gases.

Always use volatile and flammable solvents in an area with good ventilation or in a fume hood. Never use ether or other highly flammable solvents in a room with open flames or other ignition sources present.

c. Solvent Exposure Hazards

Health hazards associated with solvents include exposure by the following routes:

Inhalation: Inhalation of a solvent may cause bronchial irritation, dizziness, central nervous system depression, nausea, headache, coma, or death. Prolonged exposure to excessive concentrations of solvent vapors may cause liver or kidney damage. The consumption of alcoholic beverages can enhance these effects.

Skin Contact: Skin contact with solvents may lead to defatting, drying, and skin irritation.

Ingestion: Ingestion of a solvent may cause severe toxicological effects. Seek medical attention immediately.

In addition, some solvents (e.g., benzene) are known or suspected carcinogens.

The odor threshold for the following chemicals exceeds acceptable exposure limits. Therefore, if you can smell it, you may be overexposed---increase ventilation immediately.

- Chloroform
- Benzene
- Carbon tetrachloride
- Methylene chloride

While odor is a useful tool in assessing solvent exposure hazards, do not depend on your sense of smell alone to know when hazardous vapors are present. The odor of some chemicals is so strong that they can be detected at levels far below hazardous concentrations (e.g., xylene).

11.5 Corrosive Chemicals (Acids /Alkalis)

1. Labeling and Information

The corrosive sign is of a corrosion of a hand and/or a bar of steel. Corrosivity information can be found in the MSDS under Health and First Aid.

2. Storage

Corrosives are to be segregated from both organic and flammable materials, and acids are to be separated from bases.

Store corrosive materials low down to minimize the danger of falling from shelves.

Store in cool, dry, well-ventilated areas, away from sunlight and an area that has constant temperature.

3 Safe Handling Guidelines for Corrosives

- a. Always wear proper PPE, especially eye protection (items may include safety goggles and face shield, gloves known to be resistant to permeation or penetration, laboratory aprons, laboratory coats).
- b. Add acids and alkalis to water; never add water to acids or alkalis.
- c. Add acid to water slowly, as a great deal of heat will be formed.
- d. Use a chemical fume hood when handling fuming acids or volatile irritants (e.g., ammonium hydroxide).
- e. Provide secondary containment for storage bottles unless bottles are PVC-coated.
- f. Corrosives, especially inorganic bases (e.g., sodium hydroxide), may be very slippery; handle these chemicals with care and clean any spills, leaks, or dribbles immediately.
- g. Treat any accident resulting in contact with the skin immediately. Wash affected area with large amounts of water for at least 15 minutes. Seek immediate medical attention for chemical burns resulting from concentrated solutions.
- h. Always separate and store acids, alkalis and other corrosive materials below eye level in properly labeled storage cabinets. Refer to the MSDS's and Section 11 (Chemical Storage) of this Plan for more information.
- i. Store acids away from cyanides.
- j. Store acids and bases away from flammable liquids and solvents.
- k. Inspect containers frequently for corrosion.
- l. Make an effort to minimize quantities according to your application.
- m. A continuous flow eye wash station should be in every work area where corrosives are present.
- n. An emergency shower should also be within 100 feet of the area.

4. A Note on Perchloric Acid

CHEMICAL HYGIENE PLAN

Perchloric acid is a strong oxidizing agent and a strong dehydrating reagent that can be dangerously reactive. Perchloric acid reacts violently with organic materials. When combined with combustible material, heated perchloric acid may cause a fire or explosion. Perchloric acid at ordinary temperatures and concentrations of 70% or weaker, reacts as a strong, non-oxidizing acid. At concentrations above 70% or at elevated temperatures (usually above 160 degrees Celsius), Perchloric acid is an exceedingly strong, active oxidizer and a dehydrating agent. Anhydrous perchloric acid is unstable at room temperature and will ultimately decompose spontaneously with violent explosion.

At elevated temperatures perchloric acid is not a very strong oxidizer, but its oxidizing strength increases significantly at concentrations higher than 70%. Anhydrous perchloric acid (>85%) is very unstable and can decompose spontaneously and violently.

If possible, purchase 60% perchloric acid instead of a more concentrated grade. Always wear gloves and goggles while using perchloric acid. Be thoroughly familiar with the special hazards associated with perchloric acid before using it.

Heated digestions with perchloric acid require a special fume hood with a wash-down system. Wear adequate protective equipment (lab apron, rubber gloves and splash-proof eye protection), and work in a chemical fume hood to limit exposure of hazardous or noxious fumes. Corrosive chemicals must be transported in unbreakable containers.

Always add reagents slowly. **Add acids slowly to water and never the reverse.**

11.6 Reactive Chemicals - Explosives

1. Labeling and Information

The label affixed to the container will have information regarding the hazards of a material and must include:

- Product Name
- Manufacturer's Name and Address
- Hazards Identification

An easily recognizable symbol to communicate the hazard of a product in this case explosive may be on the label.



CHEMICAL HYGIENE PLAN

Chemical properties can be found in the MSDS. MSDS shall be reviewed before beginning work with explosive materials.

2. Handling and Storage

Before working with explosive materials, review the MSDS for the chemical properties and information on the correct handling of these chemicals.

When working or storing explosives avoid the following:

- a. Allowing picric acid to dry out;
- b. Mixing flammable chemicals with oxidants or mixing nitric acid with acetone;
- c. Flammable gas leaks; and
- d. Excessive temperature changes.

11.7 Reactive Chemicals - Oxidizers

Oxidizing chemicals are used to provide oxygen for chemical reactions, and can explode when heated or shocked. Oxidizing agents are instable and explosively unpredictable therefore, they represent a safety threat.

No labeling, information, storage or handling information included.

11.8 Toxic Chemicals

1. Labels and Information

Containers are to be clearly labeled and stored separately. Work areas must be posted with warning signs, and all employees are to adhere to proper operational and emergency procedures.

Visitors should be notified about the use of carcinogen in the laboratory work area.

2. Storage

Highly toxic chemicals must be stored according to the hazard potential and in a well-ventilated area. Containers are to be sealed with tape, and storage areas labeled with the appropriate warning signs.

3. Handling

Exercise extreme caution when working with toxic chemicals. Always wear the appropriate personal protective equipment and work in a well ventilated area. All work surfaces are to be covered with plastic trays or absorbent plastic-backed paper.

11.9 Carcinogens and Mutagens (see Appendix M for OSHA regulated carcinogens)

Safe handling of Carcinogens and Toxins

This section outlines the recommendations for general safeguards that should be observed when working with chemical carcinogens and toxins in the laboratory. These safeguards will provide protection to the laboratory worker/student from exposure to chemical carcinogens or toxins in the majority of situations.

1. Personnel Practices

PPE. Laboratory clothing that protects street clothing, such as a fully fastened laboratory coat, should be worn when chemical carcinogens and toxins are being used. Laboratory clothing should not be worn outside the laboratory area. Clothing overtly contaminated by chemical carcinogens/toxins should be removed immediately and disposed of or decontaminated prior to laundering. Gloves which are appropriate to the task and chemicals in use should be worn when handling a chemical carcinogen and toxins. Disposable gloves should be discarded after each use and immediately after overt visible contact with a chemical carcinogen or toxin.

Eye Protection. Devices to provide appropriate eye protection should be available and used in the laboratory work area. The type of device used will depend upon the hazard presented by the operation and chemical in use.

Eating, Drinking and Smoking. There should be no eating, drinking, smoking, chewing of gum or tobacco, application of cosmetics or storage of utensils, food or food containers in laboratory areas where chemical carcinogens and toxins are used or stored.

Pipetting. Mechanical pipetting aids should always be used for all pipetting procedures.

Personal Hygiene. All employees and students should wash their hands immediately after completing any procedure which contained a chemical carcinogen/toxin and when leaving the laboratory. Immediately following any contact with a carcinogen or toxin, personnel should wash, or if appropriate, shower the affected area.

2. Operational Practices

The work area needs to be identification and each entrance where chemical carcinogens and toxins are being used or stored, should have affixed to it a sign with the following warning:

CAUTION
Designated Use Area.
Select Carcinogens, Reproductive Hazards, or
Substances of High Acute Toxicity may be present.
Authorized Personnel Only.

Work areas where chemical carcinogens or toxins are being used require access control and may be entered only by persons authorized by the principal investigator or his / her designee. Maintenance, custodial and emergency personnel should be advised of the hazards that they may encounter before they are called on to enter the laboratory. Access doors to work areas should be kept closed while experiments involving chemical carcinogens or toxins are in progress.

Work Surfaces on which chemical carcinogens or toxins are used should be covered with stainless steel or plastic trays, dry absorbent plastic backed paper, or other impervious material. The protective surfaces should be decontaminated or disposed of after the procedure involving a chemical carcinogen or toxin has been completed.

CHEMICAL HYGIENE PLAN

Primary Containment Equipment. Procedures involving volatile chemical carcinogens or toxins and solid/liquid chemical carcinogens or toxins that may result in the generation of aerosols should not be conducted on the open bench but in a chemical fume hood, or a glove box. Examples of aerosol producing procedures are: Sonication; the opening of closed vessels; transfer operations; blending; open vessel centrifugation; and the application, injection or intubation of a chemical carcinogen or toxin into experimental animals. Tissue culture and other biological procedures involving chemical carcinogens may be conducted in a Class II type B Biological Safety Cabinet.

Analytical Instrumentation which produces vapors or aerosols when used with chemical carcinogens or toxins should be captured through local exhaust ventilation at the site of their production or be vented into a chemical fume hood. When a sample containing a chemical carcinogen or toxins is removed from an analytical instrument, it should be placed in a tightly stoppered sample tube or otherwise safeguarded from contaminating the laboratory. Analytical equipment that becomes overtly contaminated should not be used until it has been decontaminated.

Storage and Inventory. Stock quantities of chemical carcinogens and/ or toxins should be stored in a designated storage area or cabinet and should be located within the laboratory work area. The storage area or cabinet should have affixed to it a sign with the following warning:

CAUTION - POTENTIAL HAZARD (define hazards)

The person responsible for the storage area should maintain an inventory of stock quantities of chemical carcinogens or toxins and the inventory should include the quantities of chemical carcinogens or toxins acquired and the dates of acquisition. Storage vessels/containers should be labeled with the following warning:

CAUTION - POTENTIAL HAZARD (define hazards)

Working quantities of chemical carcinogens or toxins present in the work area should be kept to a minimum.

Transportation of chemical carcinogens or toxins from one site to another (e.g., storage area to work area) should first be placed in a durable outer container. Contaminated materials which are to be transferred from work areas to disposal areas should be placed in a closed plastic bag or other suitable impermeable and sealed primary container. The primary container should be placed in a durable outer container before being transported. The outer container should be labeled with both the name of the chemical carcinogen or toxin and the following warning:

CAUTION - POTENTIAL HAZARD (define hazard)

General housekeeping procedures which suppress the formation of aerosols such as the use of a wet mop or a vacuum cleaner equipped with a high efficiency particulate air (HEPA filter) to remove particulates should be used. Dry sweeping and mopping should not be used because of the hazard of aerosol formation. In those instances where a chemical carcinogen or contaminated material is spilled, special cleanup procedures developed for the individual compound should be employed.

Vacuum Lines should be protected (e.g., with an absorbent or liquid trap and a HEPA filter) to prevent entry of any chemical carcinogen into the system. When using a volatile carcinogen or toxin, a separate vacuum pump should be used. This device should be placed within or vented into an appropriate laboratory-type hood.

Packaging and Shipping. Chemical carcinogens or toxins should be securely packaged to withstand shocks, pressure changes, and any other conditions which might cause the leakage of contents incident to ordinary handling during transportation. Information concerning the proper methods for packaging and shipping of hazardous materials is detailed in Department of Transportation regulations 49 CFR Parts

CHEMICAL HYGIENE PLAN

170-178. Material Safety Data Sheets (MSDS must accompany chemicals that are shipped from laboratories).

Decontamination. Contaminated materials should either be decontaminated by approved procedures that decompose the chemical to produce a safe product or be removed for subsequent disposal.

Disposal. Prior to the start of any laboratory activity involving a chemical carcinogen or toxin, plans for the handling and ultimate disposal of contaminated wastes and surplus amounts of the carcinogen should be completed. The principal investigator should obtain guidance from the Department of Environmental Health and Safety in selecting the best methods available that are in compliance with Federal, State and local regulations.

3 Safe Handling for Acute and Chronic Toxins:

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

Use these chemicals in a chemical fume hood or other appropriate containment device if the material is volatile or the procedure may generate aerosols. If a chemical fume hood is used, it should be evaluated to confirm that it is performing adequately.

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

Decontaminate working surfaces with wet paper towels after completing procedures. Place the towels in plastic bags and secure. Volatile chemicals should be transported between laboratories in durable outer containers.

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

If one or more of these substances are used in large quantities, on a regular basis (three or more separate handling sessions per week), or for long periods of time (4-6 hours) a qualitative and potentially quantitative exposure assessment should be performed. Lab personnel of childbearing age should be informed of any known male and female reproductive toxins used in the laboratory. An employee who is pregnant, or planning to become pregnant, and who is working with potential reproductive toxins that might affect the fetus, should contact the Environmental Health and Safety Department to evaluate their exposure and inform her personal physician.

Section 12: Chemical Inventory

All laboratories are to maintain a chemical inventory which must be updated regularly. The inventory must list the chemicals in alphabetical order and contain the following on each chemical:

- The chemical name and the trade or common names for that chemical;
- The quantity stored;
- Date received;
- The physical state (liquid, solid or gas) and hazard profile (carcinogen);
- The storage location of the chemical.

Chemicals should not be stored beyond their shelf life which is typically determined by the manufacturer. It is required that all containers be dated with the receipt and expiration dates. In the table below, is a list on the shelf life of unstable chemicals.

Table E: Shelf Life of Unstable Chemicals

<u>Peroxide Hazard on Storage Discard After Three (3) Months</u>	
Isopropyl ether	Divinyl acetylene
Vinylidene chloride	Potassium metal
Sodium amide	
<u>Peroxide Hazard on Concentration Discard After One (1) Year</u>	
Ethyl ether	Tetrahydrofuran
Dioxane	Acetal
Methyl isobutyl ketone (glyme)	Ethylene glycol dimethyl ether
Vinyl ethers	Dicyclopentadiene
Diacetylene	Metal acetylene
Cumene	Tetrahydronaphthalene
Cyclohexane	t-Butyl alcohol
<u>Hazardous to Peroxide Initiation of Polymerization Discard After One (1) Year</u>	
Styrene	Butadiene
Tetrafluoroethylene	Chlorotrifluoroethylene
Vinyl acetylene	Vinyl acetate
Vinyl chloride	Vinyl pyridine
Chlorobutadiene (Chloroprene)	9,10-Dihydroanthracene
Indene	Dibenzocyclopentadiene

Section 13: Compressed Gas Safety

Compressed gases are used in many laboratories for analytical or instrument operations. These gases can be toxic, combustible, explosive, poisonous, corrosive, inert, or a combination of hazards. As compressed gases are under a great deal of pressure, there is the potential for simultaneous exposure to both mechanical and chemical hazards. For example, a flammable gas having a flash point lower than room temperature compounded by high rates of diffusion present a danger for fire or explosion. Thus, careful handling procedures are necessary when working with various compressed gases and cylinders; the regulators or valves used to control gas flow, and the piping used to confine gases during flow. The types of gases that may be found in a laboratory are:

Compressed - pressurized gas at a temperature greater than their boiling point (oxygen, nitrogen and argon).

Liquefied – gases stored under high pressure at a temperature greater than their boiling point (carbon dioxide, propane, butane and chlorine).

Dissolved – another container is inside the cylinder where the gas is dissolved (acetylene is a gas dissolved in acetone).

Cryogenic liquids – compressed to below their boiling points, and then condensed to form cryogenic liquid (oxygen, nitrogen and helium).

13.1 Regulatory Agencies

Various agencies are involved in setting the standards for compressed gases. OSHA has a standard for compressed gases that under 29 CFR 1910 subpart M. ANSI in conjunction with NFPA developed the NFPA55 standard. The U.S. Department of Transportation (DOT) maintains the requirements and regulations for the transportation of compressed gas cylinders. An organization that works closely with OSHA and ISO in publishing information on compressed gases is the Compressed Gas Association (CGA). CGA develops and promotes the safety standards and safe practices for the gas industry.

13.2 Cylinder Labeling

Each compressed gas cylinder received from a supplier must be labeled descriptively with the type of gas and the hazards. Cylinders are to be returned to the vendor if not labeled correctly or if there is no color-coded tags. Compressed gas cylinders may be labeled in five ways:

- a. Flammable Gas – shows a flame on a red label.
- b. Poisonous Gas -- labels show skull and crossbones.
- c. Chlorine Gas – labels are distinctly marked.
- d. Oxygen-containing Gas -- designated by a flaming letter “O”.



- e. Non-flammable Gas -- label depict a gas canister on a green background.

13.3 Handling, Storage and Transportation of Compressed Gas Cylinders

THE FOLLOWING PROCEDURES AND PRECAUTIONS ARE TO BE ENFORCED WHEN WORKING WITH COMPRESSED GASES.

- a. No cylinder is to be accepted for use from a supplier that does not have a legible label identifying the contents of the cylinder by name. Color coding as a means of identification is not reliable. Do not accept a cylinder from a supplier if the safety valve covers are not in place or properly tightened and the cylinder is possibly leaking.
- b. Do not drop, slide or drag cylinders. Use a suitable cart with a chain to transport cylinders securely from one place to another. Transport the cylinders in a manner to avoid the cylinders from violently striking each other.
- c. Gas cylinders are to be secured with either chains or straps at all times.
- d. Use the correct tool (wrench) for the removal of the cylinder cap or to open a valve, never use a screwdriver or pliers.
- e. The pressure regulator is to be attached to the cylinder before the valve is opened. Keep the valve closed at all times except when in use.
- f. Never try to fix or tamper with the pressure relief devices in the valves or cylinders.
- g. Compressed gas cylinders must be stored in well-ventilated areas and at temperatures below 125°F. All empty cylinders are to be stored separately from the full tanks.
- h. Cylinders must not be stored and used near radiators or other heat sources, and never where they can become part of an electrical circuit.
- i. Oxygen cylinders are not to be stored in the same vicinity as flammable gases. There must be a minimum of 50 feet between these materials.
- j. Materials that are greasy or oily are not to be stored around oxygen or applied to any cylinder fittings.
- k. Cylinders when in operation must be placed so that the valve is accessible at all times.
- l. Regulators are gas specific and may not be interchangeable, thus ensure that the regulator and valve fittings are compatible.
- m. Never empty a cylinder to a pressure lower than 172 kPa (25 psi/in²).
- n. Empty cylinders or ones no longer in use must be returned to the supplier.



13.4 Cylinder Operation

When using a compressed gas cylinder, the following steps should be followed:

- a. Attach the closed regulator to the cylinder without forcing the threads.
- b. Turn the delivery pressure by adjusting the screw counter-clockwise until it turns freely.
- c. Open the cylinder valve counter-clockwise slowly until the inlet gauge registers the

CHEMICAL HYGIENE PLAN

pressure of the cylinder. If the pressure of the cylinder is reading lower than expected, there may be a valve leakage.

- d. Close the flow control valve at the regulator outlet, then turn the delivery pressure by adjusting the screw clockwise until the gauge shows the required delivery pressure.
- e. Check for leaks by using the “Snoop” or soap method.
- f. For flow control adjust the flow control valve.
- g. When the cylinder is no longer in use, close the valves in a “source outward” sequence – valve, delivery pressure adjusting screw, and then the flow control valve; this will release the regulator pressure.

Section 14: Spill Response and Clean-up Guidelines

During normal operations, accidents will occur despite our best efforts to prevent them. Regardless of source, spills require immediate attention by employees knowledgeable on the spill clean-up procedure, which kit to use and the emergency response necessary, if any. All spills are to be reported and investigated.

If a situation arises that employees have to evacuate due to a hazardous spill, employees must know how to act and react during an emergency by following the emergency procedure using the acronym NEAR.

Notify
Evacuate
Assemble
Report

A spill clean-up guide must be posted for quick reference. See Appendix J for an example of a quick reference on spill clean-up.

14.1 Training

All laboratory employees/students are to be instructed on the procedure for an emergency response prior to initiating work in a laboratory. This training should inform employees/students of these basic steps:

- a. The correct way to report a fire, injury, chemical spill or any other emergency.
- b. The location of emergency safety equipment including fire extinguishers and spill kits.
- c. The locations of all emergency exits.
- d. The location of the safety manual.
- e. Where to obtain the information for emergency contact numbers.

14.2 Chemical Spills

Chemical spills must be cleaned up immediately, properly and efficiently, thus preventing exposure to toxic materials and the possibility of slips and falls. The amount of spill is not as important as the toxicity of the chemical and the potential for a fire or explosion. Report all chemical spills. Spills can be classified as small/minor or large/major.

Table F: Types of Chemical Spills

Type of Spill	Neutralizing Agent / Clean up supplies
Acid	Sodium bicarbonate
Bases	Citric Acid
Organic Solvents	Absorbent pads, charcoal if available
Mercury	Amalgam sponges
Metals e.g., sodium	Sand, Class D fire extinguishers

CHEMICAL HYGIENE PLAN

1. Small Spill Guidelines

Small spills do not cause serious danger to the life and health of employees and spread slowly. These types of spills are usually safely managed by laboratory personnel with experience in hazardous chemicals. All other types of spills are considered large and unmanageable. The following information is provided as a general guideline for spill management.

- a. Notify all personnel in the immediate area of the spill.
- b. Avoid breathing the vapors. Find out which chemical and the quantity that was spilled.
- c. Immediately attend to anyone that was injured or exposed and if necessary call for help.
- d. Wear the appropriate personal protective equipment before entering the area, and consult the MSDS for relevant information on the chemical properties.
- e. Confine and limit the spill to a small area without the risk of injury or contamination.
- f. Use the appropriate materials to neutralize and absorb inorganic acids and bases. Collect the residual and place all clean-up debris in the correct chemical waste container.
- g. All other chemicals require the appropriate spill kit. Vermiculite, dry sand or absorbent pads can be used to absorb the spill.
- h. If flammable liquid is spilled, turn off all ignition and heat sources.
- i. If a small fire develops use an appropriate fire extinguisher.
- j. Use either the Stop, Drop, and Roll procedure if an employee/student's clothing is on fire or wrap the employee/student with a fire blanket to smother the flames.
- k. Finally, clean the spill area with water.

A typical spill control kits should include:

- a. Spill control pillows are used to absorb solvents, acids, alkalis, but not hydrogen fluoride and are commercially available.
- b. Absorbents such as vermiculite, clay, sand, kitty litter and oil-dry.
- c. Neutralizing agents such as sodium carbonate or sodium bicarbonate for acid spills.
- d. Neutralizing agents such as sodium bisulfate or citric acid for alkali spills.
- e. Plastic scoops, bags and 5 gallon pails with polyethylene liners.
- f. Appropriate warnings signs and barricade tape.

2. Large Spill Guidelines

A large spill may present with a situation that is dangerous to the lives and health of employees. The following measures should be taken to ensure employee/student safety:

- a. Attend to anyone that is injured or contaminated and then remove them to a safe area.
- b. Alert all employees of the spill and if the danger involves the area beyond the spill or room, pull the fire alarm and evacuate the building.
- c. If flammable material is spilled, try to turn off all ignitable and heat sources.
- d. Do not attempt to clean up the affected area, just close all doors.
- e. Call 911 to report the emergency.
- f. Try to determine the chemical and quantity spilled and convey this information to the emergency personnel.

14.3 First Aid Guidelines

When an employee/student is injured or potentially exposed during a chemical spill attend to the individual immediately as follows:

- a. If only a small area of skin is affected during a spill, immediately flush the area with flowing water for 15 minutes. If there are no visible burns. Remove any jewelry and wash the affected area with warm water and soap.
- b. Do not try to wipe the spill off the victim's clothes instead immediately shower the individual while removing contaminated clothing. Do not use creams and lotion.
- c. Avoid breathing the vapors of the spilled chemical.
- d. Discard all contaminated clothing.
- e. Spills into the eyes require immediate flushing with tepid water for at least 15 minutes.
- f. If medical attention is required call 911.
- g. For the ingestion of chemicals, if the employee/student is awake, try giving water or milk to drink but if they become nauseous stop all fluids and call the Poison Center.
- h. In the event chemicals are inhaled, evacuate the individual into fresh air and call 911. If the employee/student cannot breathe, perform CPR but avoid being exposed to chemical poisoning.

14.4 Guidelines for Environmental Chemical Releases

A hazardous chemical spill that involves the released of chemicals into the environment unintentionally either via the sewer or fume hood must be reported immediately. Without endangering yourself, try to contain the spill at the source. Depending on the chemical spilled, the regulatory agencies need to be notified with all the relevant information.

14.5 Mercury Spills

Some thermometers used in a laboratory today still contain metallic mercury. These thermometers must be handled with care as metallic mercury is poisonous with cumulative effects that may not be reversible. Mercury can be absorbed into the body by inhalation, ingestion or contact with the skin. If a spill occurs in a well-ventilated area, it may not pose as a serious health threat but should be immediately cleaned up.

1. Handling of Mercury

It is recommended that laboratories seek alternative sources for mercury, thus eliminating its use and avoiding possible spills. If any mercury thermometers or barometers are still in use in your laboratory than a mercury spill kit is required. The use of mercury requires proper handling. All mercury containers are to be unbreakable and kept closed. Mercury vapors are odorless, colorless and tasteless. One can develop mercury poisoning from chronic inhalation exposure resulting in health issues such as emotional disturbances, memory loss, fatigue, and headaches, inflammation of mouth and gums, and unsteadiness. These symptoms are reversible when the exposure is removed but they may take years to disappear.

2. Spill Guidelines

Mercury spill kits are available from commercial vendors. These spill kits should include the following components:

- a. Protective gloves (neoprene, viton, nitrile rubber or PVC),
- b. Mercury suction pump,
- c. Elemental zinc powder or amalgam material,
- d. Sulfuric acid in a spray bottle which has been diluted to 5-10%
- e. Plastic trash bag and plastic container for amalgam,
- f. Absorbent sponge tool to work with amalgam, and
- g. Plastic sealable vial for recovered mercury.

When a mercury spill occurs, isolate the area and clean the spill immediately as follows:

- a. Wear the appropriate personal protective clothing
- b. Contain the mercury with an absorbent sponge from your kit. Once the mercury is pooled together it can be collected with the suction pump.
- c. The spill waste or breakage must be packed into a plastic container or sealable plastic bag. Attach a hazardous label to the bag to identify its contents.
- d. Do not use sulfur to clean up mercury. Zinc powder is sprinkled over the entire spill area only after the mercury has been removed.
- e. With the sponge, scrub the contaminated area working the zinc powder or sulfuric acid into a paste.
- f. Allow the paste to dry, which can then be swept up and disposed of in the waste bag.
- g. All other objects that may be contaminated should be disposed of in the waste bag as well.
- h. Wash hands, arms and face thoroughly when finished working with mercury.

Section 15: Shipping / Receiving Chemicals

The U.S. Department of Transportation regulates the shipment of hazardous materials. Anyone who packages, receives, unpacks, signs for, or transports hazardous chemicals must be trained and certified in Hazardous Materials Transportation. Warehouse personnel, shipping and receiving clerks, truck drivers, and other employees who pack or unpack hazardous materials must receive this training. Contact EH&S for more information on shipping or receiving hazardous chemicals.

Section 16: Training

Employees/students shall be provided information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

16.1 Information

The following information shall be provided at the time of initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations:

- a. The contents of 29 CFR 1910.1450 (OCCUPATIONAL EXPOSURE TO HAZARDOUS CHEMICALS IN LABORATORIES) and its appendices.
- b. The location and availability of the employer's Chemical Hygiene Plan.
- c. The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard.
- d. Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory
- e. 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 (MSDS) received from the manufacturer.

16.2 Training

It is the responsibility of the PI/supervisor to provide training on laboratory-specific hazards such as special equipment used in the lab or particularly hazardous substances. Training must initiate 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 training and education program should be a regular, continuing activity--not simply an annual presentation. It is the responsibility of the PI/supervisor to recognize when additional training is needed for his/her employees/students and to arrange for such training.

The training each employee/student receives shall include all of the following, as they apply to their work area.

- a. Hazard Detection: 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.)
- b. Chemical Hazards: The physical and health hazards of chemicals in the work area
- c. Employee Protection: 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.
- d. Emergency and Personal Protection Procedures: Every laboratory worker should know

CHEMICAL HYGIENE PLAN

the location and proper use of available protective apparel and equipment. Personnel of the laboratory should be trained in the proper use of emergency equipment and procedures.

- e. Personnel Protection: Personnel who receive, deliver, operate stockrooms or storerooms of hazardous materials/chemicals must be trained in the hazards, handling equipment, protective apparel, and relevant regulations pertaining to hazardous materials.

Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel. Laboratory personnel should be encouraged to use these information resources.

Section 17: Record Keeping

All reports, records of monitoring, samplings, training records, inspections and other like documents are to be submitted to EH&S for retention purposes unless otherwise noted.

The following table outlines a general retention period for certain records:

Table G: Record Keeping

<u>Record Description</u>	<u>Retention Period</u>
Accident or over-exposure incident reports	5 years
Records of exposure to personal or biological monitoring of hazardous chemicals and other harmful agents	Duration of employment of the exposed employee, plus 30 years.
Medical records for employees developed as a result of exposure to hazardous chemicals or harmful agent	Duration of employment of the exposed employee, plus 30 years.
Results of area air sampling	5 years
Records of laboratory inspections	5 years
Employee/Student training records	5 years in employee/student file.

Section 18: Chemical Waste Disposal

Various agencies and organizations are responsible for the regulations that control laboratory waste management. The Environmental Protection Agency issued regulations found in the 1976 Resource Conservation and Recovery Act (RCRA), 40 CFR 261 Subpart D on the *Identification and Listing of Hazardous Waste*. The U.S. DOT regulates the transporting and packaging of regulated medical waste. See, 49 CFR Part 173.197.

Hazardous waste is divided into two categories: (1) characteristically hazardous waste or (2) listed hazardous waste. Waste is considered hazardous if it meets the following criteria for quantity, concentration, physical and chemical characteristics which may cause or contribute to an increase in illness or mortality or pose a threat to human health or the environment if managed improperly.

Chemical waste is considered hazardous if it has the properties to cause or contribute to an increase in illness or mortality, pose as a threat to human health or the environment if managed improperly. Chemical waste can be divided into different types of waste according to its quantity, concentration, physical, and chemical characteristics. Chemical waste disposal has become more complicated and regulated with special requirements for waste disposal. This section will provide information on how to reduce waste as a generator, which materials are regulated and the correct disposal of chemical waste.

The disposal of chemical and biological waste has become more complicated, and the following outline will provide information on which materials are regulated; the legal method for the disposal of chemicals and biological waste; and how to reduce waste as a generator.

18.1 Hazardous Waste Management

The proper management of hazardous chemicals and waste requires the cooperation of all staff. The departmental safety committee or officer is responsible for the waste program and ensuring all waste is handled in a safe manner. In addition, all federal and state laws for generated waste are to be adhered to regarding the labeling of containers, handling, treatment, storage, transportation, and the disposal of hazardous waste with an approved, licensed disposal company. The waste program requires maintenance of correct documentation for the generation, storage and disposal of hazardous waste.

The ID number issued by the EPA must be used when labeling and disposing of waste. The amount of waste generated determines which of three classifications the laboratory will fall into as a generator:

CESQG (Conditionally exempt small quantity generator): waste which generates less than 100kg of hazardous waste and less than 1kg of acute hazardous waste (AHW) (on the P list waste) per calendar month with fewer regulations.

SQG (Small quantity generator): waste which generates between 100 – 1,000kg of hazardous waste and less than 1kg of AHW per calendar month with intermediate levels of regulation.

LQG (Large quantity generator): waste which generates more than 1,000kg of hazardous waste and 1kg or more of AHW per calendar month with the most stringent regulations.

18.2 Classification of Chemical Hazardous Waste

The RCRA and specifically 40 CFR 261.20 - 261.24 define the four fundamental characteristics of regulated chemical waste as: (1) ignitable, (2) corrosive, (3) reactive, and (4) toxic. Hazardous waste also falls into different listed categories, some are not applicable to clinical laboratories. Hazardous waste categories are listed in Appendix O. If a waste demonstrates any of the below characteristics, it is considered hazardous whether it is listed or not in Appendix O.

1. Ignitable (D001)

Waste is ignitable if the spent waste materials exhibit one or more of the following characteristics:

- a. Liquid with a flash point of less than 60°C (140°F).
- b. A material that is not liquid and capable of causing fire through friction, absorption of moisture or spontaneous chemical changes.
- c. An ignitable compressed gas.
- d. An oxidizer.
- e. The hazardous waste number is D001.

Examples of ignitable waste include, but are not limited to, common organic solvents, gases such as hydrogen, and certain nitrate salts.

2. Corrosive (D002)

Waste is corrosive when its materials meet one or more of the following criteria:

- An aqueous solution with a $\text{pH} \leq 2$ and ≥ 12.5 .
- Liquid material which corrodes steel at a rate > 6.35 millimeters (0.250 inches) per year at 55°C (130°F).
- The hazardous waste number is D002.

Examples of corrosive waste includes, but are not limited to, common laboratory acids and bases, some amines and solutions of certain metal salts (e.g., a 0.1M aqueous solution of ferric chloride has a pH of 2.0).

3. Reactive (D003)

Waste is reactive when its materials meet one or more of the following criteria:

- a. Normally unstable or reacts violently with water.

CHEMICAL HYGIENE PLAN

- b. Forms potentially explosive mixtures with water thus generating toxic gases, vapors or fumes which are harmful to the environment and our health.
- c. Cyanide or sulfide waste generates toxic gases, vapors or fumes at pH conditions between 2 and 12.5.
- d. Materials capable of detonation or explosion when heated or exposed to an ignitable source.
- e. Classified by DOT as explosive and listed as hazardous waste number D003.

Examples of reactive materials include, but are not limited to, alkali metals, peroxides, and cyanide and sulfide compounds.

4. Toxicity (D004 – D043)

A toxic waste if an extract of the solid waste is found to contain certain metals, pesticides or selected organics above specified levels, and capable of causing environmental or health damage if improperly disposed. Examples of toxic materials include the following:

Arsenic	Barium
Benzene	Cadmium
Carbon tetrachloride	Chlordane
Chlorobenzene	Chloroform
Chromium (hexavalent	<i>o</i> -Cresol
<i>m</i> -Cresol	<i>p</i> -Cresol
2,4-Dichlorophenoxyacetic acid	1,4-Dichlorobenzene
1,2-Dichloroethane	1,1-Dichloroethylene
2,4-Dinitrotoluene	Endrin
Heptachlor (and its epoxide)	Hexachlorobenzene
Hexachlorobutadiene	Hexachloroethane
Lead	Lindane (hexachlorocyclohexane)
Mercury	Methoxychlor
Methyl ethyl ketone	Nitrobenzene
Pentachlorophenol	Pyridine
Selenium	Silver
Tetrachloroethylene	Toxaphene (chlorinated camphene)
Trichloroethylene	2,4,5-Trichlorophenol
2,4,6-Trichlorophenol	2-(2,4,5-Trichlorophenoxy)propionic acid (Silvex)
Vinyl chloride	

18.3 Chemical Hazardous Waste Containers

Correct containers must be used when discarding hazardous chemicals in the laboratory. Incompatible chemical storage can be a danger to employees/students. Reference Appendix N for a list of incompatible chemicals.

Chemical waste containers must be clean, in good condition, leak-proof and suitable for the waste being discarded. Waste containers must be equipped with proper fitting caps and kept closed at all times except when adding waste materials.

All containers must be correctly labeled and identify the waste being stored. If a container leaks, the contents must be transferred to another container. See Section 14.2 – Chemical Spills on how to clean up spilt chemical materials. Containers holding waste materials that are incompatible should be separated in the storage area but still kept near the site of generation.

Waste containers are not to be overfilled; leave 10% head space for chemical expansion.

18.4 Hazardous Waste Container Labeling

All chemical waste containers are to be properly labeled to minimize the generation of unknown chemical substances. To avoid confusion or a delay in pick-up of the waste containers, they must have a “Hazardous Waste” label which includes the following information regarding the chemical waste:

- a. Name, address and the EPA ID number of generator.
- b. Accumulation start date.
- c. Chemical name, physical state and hazardous properties of the waste and all diluents.
- d. The date that the container is no longer being filled.



18.5 Hazardous Waste Segregation

All chemicals cannot be stored together and this incompatibility applies to chemical waste as well. When more than one type of chemical is being discarded, there must be segregation of the waste materials. The advantages of segregating the non-hazardous from the hazardous chemicals are in preventing any potentially dangerous reactions from occurring, protection of laboratory staff from unsafe environments, easy handling and disposing of waste and reduced disposal costs.

18.6 Hazardous Waste Accumulation Areas

A hazardous waste accumulation area is a designated area where waste can be accumulated and stored for more than 24 hours. Laboratories can only accumulate hazardous waste on-site for a

certain period of time. For small quantity generators, waste can be stored on-site up to 6,000 kg (13,200 lbs) for a period of 180 days. For large quantity generators, waste of more than 6,000 kg, the period for accumulation on-site for waste is 90 days. However, full waste containers should be removed as soon as possible.

Hazardous waste in the accumulation area is the responsibility of the laboratory until the waste has been identified, inspected, and accepted by the disposal company. The safety officer must inspect the accumulation area regularly to ensure the conditions are appropriate and all hazardous waste is handled correctly and in a safe manner. The accumulation area is to be properly signed as a hazard area with a poster of the chemical spill procedure for quick reference

18.7 Hazardous Waste and Chemical Pick-up

All chemicals and hazardous waste that is picked up and transported by the disposal company must be recorded on the mandatory EPA form, *Uniform Hazardous Waste Manifest* (see Appendix P) and accompany the waste shipment. A copy of this manifest must be given to the laboratory for recordkeeping. The laboratory must record the amount of all hazardous waste and old chemicals that are being disposed of. Chemical and hazardous pick-ups are usually weekly, but in the case of small facilities or for special circumstances such as the quick disposal of extremely toxic materials, a request for a pick-up may be necessary.

18.8 Hazardous Waste Minimization

Laboratories generate a large volume of waste per day, and according to NCCLS this can be as much as 30,000 tons of waste per year. Laboratories now face the task of reducing waste and finding chemical substitutions for some hazardous chemicals. Laboratory waste can be divided into three categories – medical, hazardous chemical and garbage waste. A primary goal of the 1976 Resource Conservation and Recovery Act (RCRA) was the reduction of generated hazardous waste. Since then, the EPA has placed a greater emphasis on the minimization of hazardous waste which will intensify in the future.

Waste minimization offers several advantages for clinical laboratories, the main advantage being the reduction in cost for disposing of hazardous chemicals. Other examples are conservation in the use of chemicals, reduction in the chemical burden for landfills, a cleaner environment, and a safer and healthier workplace for all employees. Laboratories are encouraged as generators of hazardous waste to engage in waste minimization activities and exercise prudence in handling all hazardous materials.

Recommendations for waste minimization are:

- Reduce or eliminate the use of reactive and halogenated solvent chemicals.
- Eliminate or reduce the use of oxidizers.
- Eliminate or reduce the use of highly toxic chemicals.
- If corrosive chemicals are used, neutralize waste acids or bases to a pH between 6 and 10.
- Replace hazardous materials with non-hazardous or less toxic materials.
- Reduce the quantity of chemicals ordered, to prevent disposal of unused chemicals.

CHEMICAL HYGIENE PLAN

- Reduce or eliminate mercury equipment.

The following substitutions may be used where possible:

Table H: Chemical Substitutions

Original Material	Substitute	Comments
Acetamide	Stearic acid	In phase change and freezing point depression
Chromic acid cleaning solutions	Detergents	Last resorts: KOH/Ethanol bath, acid bath.
Ethyl Ether	Methyl t-butyl ether	Avoid forming explosive peroxides
Formaldehyde	Ethanol	For storage of biological specimens
Mercury Thermometers	Red liquid thermometers	
Xylene	Limonene based extract	For histology uses

APPENDIX A

**Nova Southeastern University
Laboratory Decommissioning Checklist**

Principal Investigator:	Department:
Department Head/Chair:	Building:
Room Number:	Laboratory Closeout Date:

The purpose of this checklist is to assist PI / supervisor in safely removing hazardous materials from a laboratory and confirming that the area is free from contamination.

Chemicals	Yes	No	N/A
Refrigerators, area under sinks, fume hoods, cabinets and shelves, and bench tops have been checked for storage of hazardous materials (include shared spaces).			
All chemical containers are labeled and ready for disposal, transfer, or recycling in accordance with the University Policy and Procedures.			
Refrigerators have been emptied, defrosted and cleaned.			
Storage areas must be clean: chemical residues, drips and spills are appropriately decontaminated and cleaned up.			
All bench tops have had disposable liners/covers removed from the work surface, and surfaces have been cleaned.			
All keys to lockable chemical storage cabinets have been returned to the department.			
Controlled Substances	Yes	No	N/A
All storage areas are free of controlled substances.			
All controlled substances are disposed of or transferred according to U.S. Drug Enforcement Agency regulations and requirements.			
Compressed Gas Cylinders	Yes	No	N/A
Cylinders are properly labeled and secured.			
Cylinders not in use are disconnected and capped.			
Arrangements have been made for returning empty cylinders to vendors.			
All cylinders are labeled and ready for disposal, transfer, or recycling in accordance with the University Policy and Procedures.			
Radioactive Materials	Yes	No	N/A
Radioactive waste materials are being handled in accordance with the University Radioactive Waste Disposal Procedures.			
The removal of radioactive materials and termination surveys has been coordinated with Radiation Safety Officer in accordance with the guidelines in the University Radiation Safety Manual.			
Biological Materials	Yes	No	N/A
All work surfaces and storage areas, including walk-in coolers, freezers, refrigerators and incubators have been decontaminated.			
All inside working surfaces of the biological safety cabinets have been decontaminated by the user.			

CHEMICAL HYGIENE PLAN

Certification of the biological safety cabinet is current.			
Arrangements have been made for the decontamination and replacement of the HEPA filter in the biological safety cabinet if required.			
All sharps have been properly disinfected and placed in puncture resistant containers for disposal.			
All biological waste has been autoclaved and properly disposed of.			
Are there biological materials that need to be transferred to another location? If yes, contact EH&S for transport information.			
Has the Responsible Official been contacted to advise that experiments using Select Agents and/or Toxins will be terminated and the Select Agents and/or Toxins will be destroyed?			
Equipment	Yes	No	N/A
All equipment has been disinfected and decontaminated.			
Is any equipment going to be transferred to Surplus? If yes, then equipment must be inspected by Environmental Health and Safety personnel prior to transfer to Surplus.			
Is any equipment connected to permanent building systems being removed for transfer with the exiting investigator? If yes, contact Facilities Management			
Has all broken glass been placed in a rigid, puncture resistant container and sealed in preparation for disposal by Building Services?			
Records	Yes	No	N/A
A copy of the last current lab/chemical inventory has been provided to the department head?			

I have, to the best of my knowledge, complied with the requirements of the Nova Southeastern University Laboratory Decommissioning Checklist and am not aware of any other items or special circumstances that are not listed on this form.

Principal Investigator: _____ Date: _____

Department Chair: _____ Date: _____

Final Inspection Sign-Off

Laboratory Safety Officer: _____ Date: _____

Biological Safety Officer: _____ Date: _____

Radiation Safety Officer: _____ Date: _____

CHEMICAL HYGIENE PLAN

APPENDIX B

MSDS

HYDROCHLORIC ACID, 0.01N to 0.2N VOLUMETRIC SOLUTIONS (0.04 to 0.4%)

1. Product Identification

Synonyms: None
CAS No.: Not applicable to mixtures.
Molecular Weight: Not applicable to mixtures.
Chemical Formula: Not applicable.
Product Codes:
J.T. Baker: 0326, 5611, 5614, 5621
Mallinckrodt: 2853

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Hydrogen Chloride	7647-01-0	0.04 - 0.4%	Yes
Water	7732-18-5	> 99%	No

3. Hazards Identification

Emergency Overview

As part of good industrial and personal hygiene and safety procedure, avoid all unnecessary exposure to the chemical substance and ensure prompt removal from skin, eyes and clothing.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 0 - None
Flammability Rating: 0 - None
Reactivity Rating: 0 - None
Contact Rating: 1 - Slight
Lab Protective Equip: GOGGLES; LAB COAT; PROPER GLOVES
Storage Color Code: Green (General Storage)

Potential Health Effects

Inhalation:
Not expected to be a health hazard.
Ingestion:
Large oral doses may cause gastrointestinal disturbances.
Skin Contact:
No adverse effects expected.
Eye Contact:
May cause irritation, redness and pain.
Chronic Exposure:
No information found.
Aggravation of Pre-existing Conditions:
No information found.

4. First Aid Measures

Inhalation:
Not expected to require first aid measures.
Ingestion:
Give several glasses of water to drink to dilute. If large amounts were swallowed, get medical advice.
Skin Contact:
Not expected to require first aid measures.
Eye Contact:
Wash thoroughly with running water. Get medical advice if irritation develops.

CHEMICAL HYGIENE PLAN

APPENDIX B: MSDS CONTINUED

5. Fire Fighting Measures

Fire:

Not considered to be a fire hazard.

Explosion:

Not considered to be an explosion hazard.

Fire Extinguishing Media:

Use any means suitable for extinguishing surrounding fire.

Special Information:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Contain and recover liquid when possible. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust.

J. T. Baker NEUTRASORB® acid neutralizers are recommended for spills of this product.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Protect from freezing. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:

Not applicable.

Ventilation System:

Not expected to require any special ventilation.

Personal Respirators (NIOSH Approved):

Not expected to require personal respirator usage.

Skin Protection:

Wear protective gloves and clean body-covering clothing.

Eye Protection:

Safety glasses. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:

Clear, colorless solution.

Odor:

Odorless.

Solubility:

Infinitely soluble.

Specific Gravity:

ca. 1.0

pH:

No information found.

% Volatiles by volume @ 21C (70F):

> 99

Boiling Point:

ca. 100C (ca. 212F)

Melting Point:

ca. 0C (ca. 32F)

Vapor Density (Air=1):

Essentially the same as water.

Vapor Pressure (mm Hg):

Essentially the same as water.

Evaporation Rate (BuAc=1):

Essentially the same as water.

CHEMICAL HYGIENE PLAN

APPENDIX B: MSDS CONTINUED

10. Stability and Reactivity

Stability:

Stable under ordinary conditions of use and storage.

Hazardous Decomposition Products:

No information found.

Hazardous Polymerization:

Will not occur.

Incompatibilities:

No incompatibility data found.

Conditions to Avoid:

No information found.

11. Toxicological Information

-----\Cancer Lists\-----

---NTP Carcinogen---

Ingredient	Known	Anticipated	IARC Category
Hydrogen Chloride (7647-01-0)	No	No	3
Water (7732-18-5)	No	No	None

12. Ecological Information

Environmental Fate:

No information found.

Environmental Toxicity:

No information found.

13. Disposal Considerations

Dilute with water and flush to sewer if local ordinances allow, otherwise, whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: HYDROCHLORIC ACID SOLUTION

Hazard Class: 8

UN/NA: UN1789

Packing Group: III

Information reported for product/size: 20L

International (Water, I.M.O.)

Proper Shipping Name: HYDROCHLORIC ACID SOLUTION

Hazard Class: 8

UN/NA: UN1789

Packing Group: III

Information reported for product/size: 20L

International (Air, I.C.A.O.)

Proper Shipping Name: HYDROCHLORIC ACID SOLUTION

Hazard Class: 8

UN/NA: UN1789

Packing Group: III

Information reported for product/size: 20L

15. Regulatory Information

-----\Chemical Inventory Status - Part 1\-----

Ingredient	TSCA	EC	Japan	Australia
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CHEMICAL HYGIENE PLAN

APPENDIX B: MSDS CONTINUED

Hydrogen Chloride (7647-01-0) Yes Yes Yes Yes
Water (7732-18-5) Yes Yes Yes Yes

-----\Chemical Inventory Status - Part 2\-----

--Canada--
Ingredient Korea DSL NDSL Phil.

Hydrogen Chloride (7647-01-0) Yes Yes No Yes
Water (7732-18-5) Yes Yes No Yes

-----\Federal, State & International Regulations - Part 1\-----

-SARA 302- -----SARA 313-----
Ingredient RQ TPQ List Chemical Catg.

Hydrogen Chloride (7647-01-0) 5000 500* Yes No
Water (7732-18-5) No No No No

-----\Federal, State & International Regulations - Part 2\-----

-RCRA- -TSCA-
Ingredient CERCLA 261.33 8(d)

Hydrogen Chloride (7647-01-0) 5000 No No
Water (7732-18-5) No No No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: No Chronic: No Fire: No Pressure: No
Reactivity: No (Mixture / Liquid)

Australian Hazchem Code: None allocated.

Poison Schedule: None allocated.

WHMIS:

This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: 0 Flammability: 0 Reactivity: 0

Label Hazard Warning:

As part of good industrial and personal hygiene and safety procedure, avoid all unnecessary exposure to the chemical substance and ensure prompt removal from skin, eyes and clothing.

Label Precautions:

None.

Label First Aid:

Not applicable.

Product Use:

Laboratory Reagent.

Revision Information:

MSDS Section(s) changed since last revision of document include: 9.

Disclaimer:

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APPENDIX C

HMIS - HAZARDOUS MATERIALS IDENTIFICATION SYSTEM

HMIS Hazardous Materials Identification System



PERSONAL PROTECTION INDEX	
A	G + H + I + J + K + X
B	H + I + J + K + X
C	I + J + K + X
D	J + K + X
E	K + X
F	X

A	Safety Glasses	N	Spill/Leak Control	O	Protective Clothing	P	Protective Footwear	Q	Boots	R	Cybernetic Appliance	S	Special Handling
t	First Aid Kit	U	Respirator	W	Welding Mask	Y	Eye Protection	Z	Additional Information				

Consult your supervisor or S.O.P. for "SPECIAL" handling directions

HMIS HEALTH HAZARD RATING CHART	
* CHRONIC HAZARD	Chronic (long-term) health effects may result repeated overexposure.
0=MINIMAL HAZARD	No significant risk to health.
1=SLIGHT HAZARD	Irritation or minor reversible injury possible.
2=MODERATE HAZARD	Temporary or minor injury may occur.
3=SERIOUS HAZARD	Major injury likely unless prompt action is taken and medical treatment is given.
4=SEVERE HAZARD	Life-threatening, major or permanent damage may result from single or repeated overexposures.

APPENDIX C: HMIS CONTINUED

HMIS Hazardous Materials Identification System

HMIS FLAMMABILITY HAZARD RATING CHART	
0=MINIMAL HAZARD	Materials that will not burn.
1=SLIGHT HAZARD	Materials that must be preheated before ignition will occur. Includes liquids, solids and semi solids having a flash point above 200° F. (Class IIIB)
2=MODERATE HAZARD	Materials which must be moderately heated or exposed to high ambient temperatures before ignition will occur. Includes liquids having a flash point at or above 100° F but below 200° F. (Classes II & IIIA)
3=SERIOUS HAZARD	Materials capable of ignition under almost all normal temperature conditions. Includes flammable liquids with flash points below 73° F and boiling points above 100° F, as well as liquids with flash points between 73° F and 100° F. (Classes IB & IC)
4=SEVERE HAZARD	Flammable gases, or very volatile flammable liquids with flash points below 73° F, and boiling points below 100° F. Materials may ignite spontaneously with air. (Class IA)

HMIS PHYSICAL HAZARD RATING CHART	
0=MINIMAL HAZARD	Materials that are normally stable, under fire conditions and will not react to water, polymerize, decompose, condense or self react.
1=SLIGHT HAZARD	Materials that are normally stable but can become unstable at high temperature and pressures. Materials may react non-violently with water or undergo hazardous polymerization in the absence of inhibitors.
2=MODERATE HAZARD	Materials that are unstable and may undergo violent chemical change at normal temperature and pressure with low risk for explosion. Materials may react violently with water or form peroxides upon exposure to air.
3=SERIOUS HAZARD	Materials that may form explosive mixtures with water are capable of detonation or explosive reaction in the presence of a strong initiating source or undergo chemical change at normal temperature and pressure with moderate risk of explosion.
4=SEVERE HAZARD	Materials that are readily, capable of water reaction, detonation or explosive decomposition at normal temperatures and pressures.

APPENDIX D

CHEMICAL STORAGE AND LABELING

Maximum Allowable Size of Containers and Portable Tanks

Container Type	Flammable Class			Combustible Class	
	IA	IB	IC	II	III
Glass	1 pt	1 qt	1 gal	1 gal	5 gal
Metal or Approved Plastic	1 gal	5 gal	5 gal	5 gal	5 gal
Safety Cans	2.6 gal	5 gal	5 gal	5 gal	5 gal
Metal Containers (DOT spec)	1 gal	5 gal	5 gal	60 gal	60 gal
Approved Metal Portable Tanks	660 gal	660 gal	660 gal	660 gal	660 gal
Polyethylene (DOT Spec.34, UN1H1)	1 gal	5 gal	5 gal	60 gal	60 gal

Source: NFPA 45 and 29CFR 1910.106

Storage Limits for Flammable and Combustible Liquids: B Classification with Sprinkler System

Class of Liquid	Flash Point (°C)	Amount (gallons per 100 square feet)
Class I Flammable	Below 38	4
Class II Combustible	38-60	4
Class IIIA Combustible	60-93	12
Class IIIB Combustible	Above 93	Unlimited

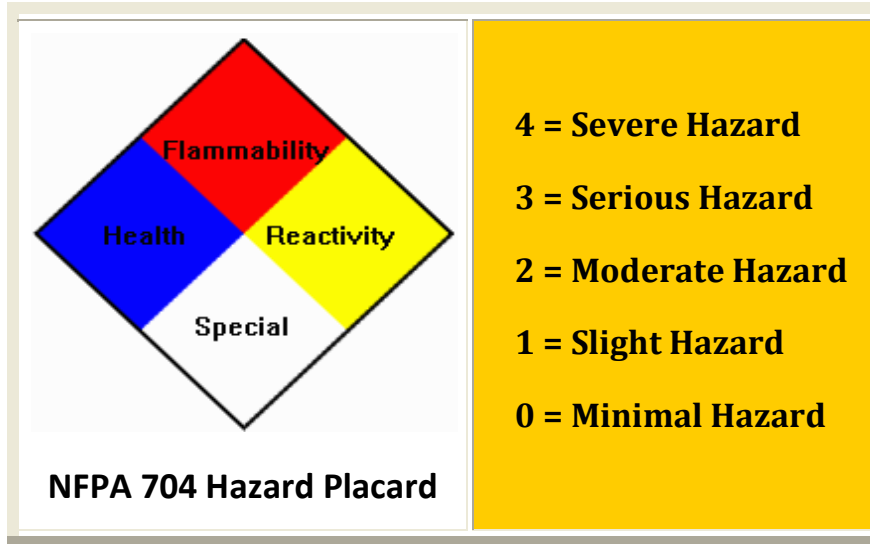
Source: 29 CFR 1910.106

Appropriate Hazard Warnings Signs



APPENDIX D: CONTINUED

NFPA 704 or HMIS placards



General Rating Summary

Health (Blue)
<p>4 Danger May be fatal on short exposure. Specialized protective equipment required</p> <p>3 Warning Corrosive or toxic. Avoid skin contact or inhalation</p> <p>2 Warning May be harmful if inhaled or absorbed</p> <p>1 Caution May be irritating</p> <p>0 No unusual hazard</p>
Flammability (Red)
<p>4 Danger Flammable gas or extremely flammable liquid</p> <p>3 Warning Flammable liquid flash point below 100° F</p> <p>2 Caution Combustible liquid flash point of 100° to 200° F</p> <p>1 Combustible if heated</p> <p>0 Not combustible</p>
Reactivity (Yellow)
<p>4 Danger Explosive material at room temperature</p> <p>3 Danger May be explosive if shocked, heated under confinement or mixed with water</p> <p>2 Warning Unstable or may react violently if mixed with water</p> <p>1 Caution May react if heated or mixed with water but not violently</p> <p>0 Stable Not reactive when mixed with water</p>
Special Notice Key (White)
<p>W Water Reactive</p> <p>OX Oxidizing Agent</p>

APPENDIX E

HAZARD COMMUNICATION - EMPLOYEE TRAINING CERTIFICATION

LOGO AND NAME

I acknowledge that I have received Hazard Communication Training and been informed about chemical labeling, material safety data sheets and training requirements of the Right-to-Know (RTK) law. I have been shown written documentation on the Hazard Communication Standard, informed of the locations for all SOP's relating to chemical hazards, the MSDS information and chemical inventory lists.

Employee Name: _____
(print)

Phone: _____ Title: _____

Work area or department: _____

Manager/Supervisor _____

Employee Signature: _____

Date: _____

APPENDIX F

**EYEWASH MAINTENANCE
WEEKLY LOG SHEET**

JANUARY	Tester Initials	JULY	Tester Initials
Week 1		Week 1	
Week 2		Week 2	
Week 3		Week 3	
Week 4		Week 4	
FEBRUARY	Tester Initials	AUGUST	Tester Initials
Week 1		Week 1	
Week 2		Week 2	
Week 3		Week 3	
Week 4		Week 4	
MARCH	Tester Initials	SEPTEMBER	Tester Initials
Week 1		Week 1	
Week 2		Week 2	
Week 3		Week 3	
Week 4		Week 4	
APRIL	Tester Initials	OCTOBER	Tester Initials
Week 1		Week 1	
Week 2		Week 2	
Week 3		Week 3	
Week 4		Week 4	
MAY	Tester Initials	NOVEMBER	Tester Initials
Week 1		Week 1	
Week 2		Week 2	
Week 3		Week 3	
Week 4		Week 4	
JUNE	Tester Initials	DECEMBER	Tester Initials
Week 1		Week 1	
Week 2		Week 2	
Week 3		Week 3	
Week 4		Week 4	

**** Check for adequate pressure and clear water to flush the eyes 15 minutes in the event of exposure.**

APPENDIX G

Personal Protective Equipment Types

Face and Eye Protection	Welding Helmets	Head Protection
<p>Spectacles w/ No side shield Half side shield Full side shield Detachable side shield Non-removable lens Lift front Headband temple</p> <p>Cover goggles w/ No ventilation Indirect ventilation Direct ventilation</p> <p>Cut goggles w/ Direct ventilation Indirect ventilation</p> <p>Face Shield</p>	<p>Burning Goggles</p> <p>Welding Helmets w/ Stationary window Lift front window Hand held</p>	<p>Helmets by Type: Type 1: Full brim 1.25” side Type 2: No brim, forward peak</p> <p>Helmets by Class:</p> <p>Class A – General service w/limited voltage protection</p> <p>Class B – Utility service w/high voltage protection</p> <p>Class C – Special service No voltage protection</p> <p>Class D – Fire fighters full brim w/ear flaps and chin strap</p> <p>Hair enclosures</p>
Foot and Leg	Electrical Protection*	Fall Protection
<p>Safety shoes/boots w/ Impact resistant toe Metal insoles Metatarsal guards Chemical Resistant Electrical protection Wet slippery surfaces Cold weather protection</p> <p>Leggings Molten metal and welding</p>	<p>Insulating Blankets Matting Covers Line Hose Gloves Sleeves Hot Stick</p> <p>*Must be capable of withstanding imposed voltage</p>	<p>Safety Belts*</p> <p>Safety harnesses</p> <p>Lifelines</p> <p>Lanyards</p> <p>*No safety belts for fall protection after 1-1-98.</p>
Arm and Hand Protection	Body Protection	
<p>Types Gloves Hand Pads Sleeves Wristlets</p>	<p>Types Vests Jackets Aprons Coveralls Full Body Suits</p>	

APPENDIX H

HAZARD ASSESSMENT FORM

Use this form as a guide to help identify the hazards in each work area.

Job Classification: _____ Area: _____

Date: _____ Assessor: _____

HEAD HAZARDS: These can include working under machinery or processes that might cause materials or objects to fall, working below other workers, energized equipment and working with chemicals.

Check which is appropriate Description of Hazard: _____
for each hazard:

- Burn yes no _____
- Chemical Splash yes no _____
- Electrical Shock yes no _____
- Impact yes no _____

EYE HAZARDS: These can include chipping, grinding, sanding, welding, woodworking, furnace operations, working with acids, or chemicals.

Check which is appropriate Description of Hazard: _____
for each hazard:

- Light/radiation yes no _____
- Chemicals yes no _____
- Dust yes no _____
- Heat yes no _____
- Impact yes no _____

HAND HAZARDS: These can include working with chemicals, with hot objects, and cutting materials.

Check which is appropriate Description of Hazard: _____
for each hazard:

- Puncture yes no _____
- Burns yes no _____
- Chemical Exposure yes no _____
- Cuts/Abrasions yes no _____

CHEMICAL HYGIENE PLAN

APPENDIX H: CONTINUED

FOOT HAZARDS: These can include handling//carrying materials that may be dropped, and working with chemicals.

Check which is appropriate Description of Hazard: _____
for each hazard:

Impact	yes <input type="checkbox"/>	no <input type="checkbox"/>	_____
Compression	yes <input type="checkbox"/>	no <input type="checkbox"/>	_____
Puncture	yes <input type="checkbox"/>	no <input type="checkbox"/>	_____
Chemical Exposure	yes <input type="checkbox"/>	no <input type="checkbox"/>	_____

It has been determined from the Personal Protective Equipment Assessment that the following personal protective equipment (PPE) is required for: _____
(Job Classification)

HEAD HAZARDS/PPE REQUIRED: _____

EYE HAZARDS/PPE REQUIRED: _____

HAND HAZARDS/PPE REQUIRED: _____

FOOT HAZARDS/PPE REQUIRED: _____

CERTIFICATION OF HAZARD ASSESSMENT

The workplace has been assessed for hazards which may be reduced through the use of selected Personal Protective Equipment. This assessment is in accordance with 29 CFR 1910.132 and its related standards, 29 CFR 1910.140. The attached survey form(s) serve as detail supporting the analysis as to the individual work area and possible hazards associated with each function.

Surveyed by: _____ Title: _____

Certified by: _____ Title: _____

Date surveyed: _____ Date certified: _____

APPENDIX I

GLOVE SELECTION CHART

Gloves	Usage	Comments	Recommended for	Not recommended for
Latex (Natural rubber) low cost	Incidental contact	Good for biological and water-based materials. Poor for organic solvents. Little chemical protection. Can puncture holes. Can cause or trigger latex allergies	Weak Acids, Weak bases, alcohols, aqueous solutions	Oils, greases and organics
Nitrile (synthetic rubber) low cost	Incidental contact	Good for solvents, oils, greases, and some acids and bases. Clear indication of tears and breaks. Good alternative for those with latex allergies	Oils, greases, acids, caustics, aliphatic solvents	Aromatic solvents, many ketones, esters, many chlorinated solvents
Butyl (synthetic rubber)	Extended contact	Good for ketones and esters. Poor for gasoline, aromatic, and halogenated hydrocarbons	Aldehydes, ketones, esters, glycol ethers, polar organic solvents	Aliphatic, aromatic and chlorinated solvents
Neoprene (synthetic rubber) medium cost	Extended contact	Good for acids, bases, alcohols, fuels, peroxides, hydrocarbons, and phenols.	Oxidizing acids, bases, alcohols, aniline, phenol, glycol ethers	Chlorinated solvents
PVA (poly-vinyl alcohol)	Specific use	Good for aromatic and chlorinated solvents. Poor for water-based solutions	A wide range of aliphatic, aromatic and chlorinated solvents, ketones	Acids, alcohols, bases, water
PVC (poly-vinyl chloride)	Specific use	Good for acids, bases, oils, fats, peroxides, and amines. Good resistance to abrasions. Poor for most organic solvents	Strong acids and bases, salts, other aqueous solutions, alcohols, glycol ethers	Aliphatic, aromatic and chlorinated solvents, aldehydes, ketones.
Viton (Fluoro-elastimer)	Extended use	Good for chlorinated and aromatic solvents. Good resistance to cuts and abrasions. Poor for ketones.	Aromatic, aliphatic and chlorinated solvents, and alcohols	Some ketones, esters, amines
Silver Shield(laminate)			Wide range of solvents, acids and bases	

APPENDIX J

COMMON LABORATORY CORROSIVES

ORGANIC ACIDS

Formic Acid
Acetic Acid (Glacial)
Propionic Acid
Butyric Acid
Chloroacetic Acid
Trichloroacetic Acid
Acetyl Chloride
Acetyl Bromide
Chloroacetyl Chloride
Oxalic Acid
Propionyl Chloride
Propionyl Bromide
Acetic Anhydride
Methyl Chloroformate
Dimethyl Sulfate
Chlorotrimethylsilane
Dichlorodimethylsilane
Phenol
Benzoyl Chloride
Benzoyl Bromide
Benzyl Chloride
Benzyl Bromide
Salicylic Acid

ORGANIC BASES

Ethylenediamine
Ethylimine
Tetramethylethylenediamine
Hexamethylenediamine
Trimethylamine aq. soln.
Triethylamine
Phenylhydrazine
Piperazine
Hydroxylamine
Tetramethylammonium Hydroxide

ELEMENTS

Fluorine (gas)
Chlorine (gas)
Bromine (liquid)
Iodine (crystal)
Phosphorus

INORGANIC BASES

Ammonium Hydroxide
Calcium Hydroxide
Sodium Hydroxide
Potassium Hydroxide
Calcium Hydride
Sodium Hydride
Hydrazine
Ammonium Sulfide
Calcium Oxide

INORGANIC ACIDS

Hydrofluoric Acid
Hydrochloric Acid
Hydrobromic Acid
Hydriodic Acid
Sulfuric Acid
Chromerge™
No-Chromix™
Chlorosulfonic Acid
Sulfuryl Chloride
Bromine Pentafluoride
Thionyl Chloride
Tin Chloride
Tin Bromide
Titanium Tetrachloride
Perchloric Acid
Nitric Acid
Phosphoric Acid
Phosphorus Trichloride
Phosphorus Tribromide
Phosphorus
Pentachloride
Phosphorus Pentoxide

ACID SALTS

Aluminum Trichloride
Antimony Trichloride
Ammonium Bifluoride
Calcium Fluoride
Ferric Chloride
Sodium Bisulfate
Sodium Fluoride

APPENDIX K

COMMON LABORATORY OXIDIZERS

Oxidizers react with other chemicals by giving off electrons and undergoing reduction. Uncontrolled reactions of oxidizers may result in a fire or an explosion, causing severe property damage or personal injury. Use oxidizers with extreme care and caution and follow all safe handling guidelines specified in the MSDS.

Bleach	Nitrites
Bromates	Nitrous oxide
Bromine	Ozanates
Butadiene	Oxides
Chlorates	Oxygen
Chloric Acid	Oxygen difluoride
Chlorine	Ozone
Chlorite	Peracetic Acid
Chromates	Perhaloate
Chromic Acid	Perborates
Dichromates	Percarbonates
Fluorine	Perchlorates
Haloate	Perchloric Acid
Halogens	Permanganates
Hydrogen Peroxide	Peroxides
Hypochlorites	Persulfate
Iodates	Sodium Borate Perhydrate
Mineral Acid	Sulfuric Acid
Nitrates	
Nitric Acid	

APPENDIX L

Classes of Peroxidizable Chemicals

A. Chemicals that form explosive levels of peroxides without concentration

Butadiene ^a	Divinylacetylene	Tetrafluoroethylene ^a	Vinylidene chloride
Chloroprene ^a	Isopropyl ether		

B. Chemicals that form explosive levels of peroxides on concentration

Acetal	Diacetylene	2-Hexanol	2-Phenylethanol
Acetaldehyde	Dicyclopentadiene	Methylacetylene	2-Propanol
Benzyl alcohol	Diethyl ether	3-Methyl-1-butanol	Tetrahydroforan
2-Butanol	Diethylene glycol	Methylcyclopentane	Tetrahydronaphthalene
Cumene	dimethyl ether(diglyme)	Methyl isobutyl ketone	Vinyl ethers
Cyclohexanol	Dioxanes	4-Methyl-2-pentanol	Other secondary alcohols
2-Cyclohexen-1-ol	Ethylene glycol	2-Penten-1-ol	
Cyclohexene	dimethyl ether (glyme)	4-Penten-1-ol	
Decahydronaphthalene	4-Heptanol	1-Phenylethanol	

C. Chemicals that may autopolymerize as a result of peroxide accumulation

Acrylic acid ^b	Chlorotrifluoroethylene	Vinyl acetate	Vinyladiene chloride
Acrylonitrile ^b	Methyl methacrylate ^b	Vinylacetylene	
Butadiene ^c	Styrene	Vinyl chloride	
Chloroprene ^c	Tetrafluoroethylene ^c	Vinylpyridine	

D. Chemicals that may form peroxides but cannot clearly be placed in sections A-C

Acrolein ^d	tert-Butyl methyl ether	Di(1-propynyl) ether ^f	4-Methyl-2-pentanone
Allyl ether ^d	n-Butyl phenyl ether	Di(2-propynyl) ether	n-Methylphenetole
Allyl ethyl ether	n-Butyl vinyl ether	Di-n-propoxymethane ^d	2-Methyltetrahydrofuran
Allyl phenyl ether	Chloroacetaldehyde	1,2-Epoxy-3-isopropoxypropane ^d	3-Methoxy-1-butyl acetate
	diethylacetal		
p-(n-Amyloxy)benzoyl chloride	2-Chlorobutadiene	1,2-Epoxy-3-phenoxypropane	2-Methoxyethanol
n-Amyl ether	1-(2-Chloroethoxy)-2-phen-	Ethoxyacetophenone	3-Methoxyethyl acetate
Benzyl n-butyl ether ^d	oxyethane	1-(2-Ethoxyethoxy)ethyl acetate	2-Methoxyethyl vinyl ether
Benzyl ether ^d	Chloroethylene	2-Ethoxyethyl acetate	Methoxy-1,3,5,7-cycloocta
Benzyl ethyl ether ^d	Chloromethyl methyl ether ^e	(2-Ethoxyethyl)-o-benzoyl	tetraene
Benzyl methyl ether	β-Chlorophenetole	benzoate	β-Methoxypropionitrile
Benzyl 1-naphthyl ether ^d	o-Chlorophenetole	1-Ethoxynaphthalene	m-Nitrophenetole
1,2-Bis(2-chloroethoxy)ethane	p-Chlorophenetole	o,p-Ethoxyphenyl isocyanate	1-Octene
Bis(2-ethoxyethyl) ether	Cyclooctene ^d	1-Ethoxy-2-propyne	Oxybis(2-ethyl acetate)
Bis(2-(methoxyethoxy)ethyl)	Cyclopropyl methyl ether	3-Ethoxypropionitrile	Oxybis(2-ethyl benzoate)
ether	Diallyl ether ^d	2-Ethylacrylaldehyde oxime	β,β-Oxydipropionitrile
Bis(2-chloroethyl) ether	p-Di-n-butoxybenzene	2-Ethylbutanol	1-Pentene
Bis(2-ethoxyethyl) adipate	1,2-Dibenzoyloxyethane ^d	Ethyl β-ethoxypropionate	Phenoxyacetyl chloride
Bis(2-ethoxyethyl) phthalate	p-Dibenzoyloxybenzened	2-Ethylhexanal	â-Phenoxypropionyl chloride
Bis(2-methoxyethyl)	1,2-Dichloroethyl ethyl	Ethyl vinyl ether	Phenyl o-propyl ether
carbonate	ether		
Bis(2-methoxyethyl) ether	2,4-Dichlorophenetole	Furan	p-Phenylphenetone
Bis(2-methoxyethyl)phthalate	Diethoxymethaned	2,5-Hexadiyn-1-ol	n-Propylether
Bis(2-methoxymethyl) adipate	2,2-Diethoxypropane	4,5-Hexadien-2-yn-1-ol	n-Propyl isopropyl ether

CHEMICAL HYGIENE PLAN

APPENDIX L:

Bis(2-n-butoxyethyl) phthalate	Diethyl ethoxymethylenemalonate	n-Hexyl ether	Sodium 8,11,14-eicosa
Bis(2-phenoxyethyl) ether	Diethyl fumarated	o,p-Iodophenetole	tetraenoate
Bis(4-chlorobutyl) ether	Diethyl acetald	Isoamyl benzyl etherd	Sodium ethoxyacetylidef
Bis(chloromethyl) ethere	Diethylketenef	Isoamyl etherd	Tetrahydropyran
2-Bromomethyl ethyl ether	m,o,p-Diethoxybenzene	Isobutyl vinyl ether	Triethylene glycol diacetate
β-Bromophenetole	1,2-Diethoxyethane	Isophoroned	Triethylene glycol dipropionate
o-Bromophenetole	Dimethoxymethaned	p-Isopropoxypropionitriled	1,3,3-Trimethoxypropened
p-Bromophenetole	1,1-Dimethoxyethaned	Isopropyl 2,4,5-trichlorophenoxy-	1,1,2,3-Tetrachloro-1,3-
3-Bromopropyl phenyl ether	Dimethylketenef	acetate	butadiene
1,3-Butadiyne	3,3-Dimethoxypropene	Limonene	4-Vinyl cyclohexene
Buten-3-yne	2,4-Dinitrophenetole	1,5-p-Methadiene	Vinylencarbonate
tert-Butyl ethyl ether	1,3-Dioxepaned	Methyl p-(n-amyloxy)benzoate	Vinylidene chlorided

a

When stored as a liquid monomer

b Although these chemicals form peroxides, no explosions involving these monomers

c

When stored in liquid form, these chemicals form explosive levels of peroxides without concentration. They may also be stored as a gas

in gas cylinders. When stored as a gas, these chemicals may autopolymerize as a result of peroxide accumulation.

d These chemicals easily form peroxides and should probably be considered under part B.

e

OSHA-regulated carcinogen **f** Extremely reactive and unstable compound.

APPENDIX M

OSHA REGULATED CARCINOGENS

<http://www.lbl.gov/ehs/chsp/html>

Regulated by OSHA as a carcinogen. These include:

- 2-Acetylaminofluorene
- Acrylonitrile
- 4-Aminodiphenyl
- Asbestos
- Benzene
- Benzidine (and its salts)
- 1,3 - Butadiene
- bis-Chloromethyl ether
- Cadmium
- Coke oven emissions
- Dibromochloropropane (DBCP)
- 3,3'-Dichlorobenzidine (and its salts)
- 4-Dimethylaminoazobenzene
- Ethylene dibromide
- Ethyleneimine
- Ethylene oxide
- Formaldehyde
- Inorganic Arsenic
- Methyl chloromethyl ether
- 4,4'-Methylene bis(2-chloroaniline)
- Methylene chloride
- Methylenedianiline
- alpha-Naphthylamine
- beta-Naphthylamine
- 4-Nitrobiphenyl
- N-Nitrosodimethylamine
- beta-Propiolactone
- Vinyl chloride

CHEMICAL HYGIENE PLAN

APPENDIX N

INCOMPATIBLE CHEMICALS

The following is a partial listing of incompatible chemicals. A more complete listing may be found on the NFPA website.

CHEMICAL	IS INCOMPATIBLE WITH
Acetic acid	Chromic acid, nitric acid, hydroxyl-containing compounds, ethylene glycol, perchloric acid, peroxides, and permanganates
Acetone	Concentrated sulfuric and nitric acid mixtures or chloroform and bases
Acetylene	Copper tubing, halides, silver, mercury and their compounds
Alkali metals	Aluminum, calcium, lithium, magnesium, potassium and sodium with water or chlorinated hydrocarbon, carbon dioxide, halogens
Ammonia(anhydrous)	Mercury, halogens, calcium hypochlorite, hydrogen fluoride
Aniline	Nitric acid and hydrogen peroxide
Azides	Acids
Bromine	Ammonia, acetylene, butadiene, butane, hydrogen, sodium carbide, turpentine
Calcium oxide	Water
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic and combustible materials
Chromic acid	Acetic acid, alcohol, camphor, flammable liquids, glycerol, naphthalene
Chlorine	Ammonia, acetylene, butadiene, benzene and other petroleum fractions, hydrogen, sodium carbides, powdered metals
Copper, salts	Acetylene, hydrogen peroxide
Cyanides	Acids
Ethylenediamine	Greater than 3 percent with methylene chloride (explosive)
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, halogens, nitric acid, sodium peroxide
Hydrocarbons	(Butane, Halogens, chromic acid, peroxides Propane, Benzene)
Hydrogen peroxide	Copper, chromium, iron, most metals and their salts, flammable fluids, aniline, and nitromethane
Hydrogen sulfide	Nitric acid and oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia
Mercury	Acetylene, hydrogen
Methylene chloride	Greater than 3 percent ethylenediamine (explosive)
Nitric acid	Acetic, chromic and hydrochloric acids, aniline, carbon, hydrogen sulfide, flammable fluids, or gases which are readily nitrated
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, and gases
Oxalic acid	Mercury, silver
Perchloric acid	Acetic anhydride, alcohol, organic materials, e.g., wood, paper, grease, and oils
Phosphorus	Air, alkalis, oxygen, reducing agents
Phosphorus pentoxide	Water
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Sodium	Carbon dioxide, carbon tetrachloride, water
Sodium peroxide	Any oxidizable substances; acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethyl acetate, methanol
Sulfides	Acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate
Tellurides	Reducing agents

APPENDIX O

LISTED HAZARDOUS WASTE

F List - addresses wastes from nonspecific sources (e.g., spent solvents) and places them into several subcategories (or codes). The five codes that are most applicable to laboratory wastes are:

- **F001** Code - spent solvent mixtures and blends used for degreasing. Contain before use, a total of 10% or more (by volume) of one or more of the following halogenated solvents:

tetrachloroethylene	methylene chloride
trichloroethylene	1,1,1-trichloroethane
carbon tetrachloride	Chlorinated fluorocarbons

- **F002** Code - spent solvent mixtures and blends. Contain before use, a total of 10% or more (by volume) of one or more of the following halogenated solvents:

tetrachloroethylene	methylene chloride
trichloroethylene	1,1,1-trichloroethane
chlorobenzene	1,1,2-trichloro-1,2,2-trifluoroethane
Ortho-dichlorobenzene	trichlorofluoromethane
1,1,2-trichloroethane	

- **F003** Code - spent solvent mixtures and blends. Contains before use, a total of 10% or more (by volume) of one or more of the following non-halogenated solvents:

xylene	acetone
Ethyl acetate	ethyl benzene
methanol ethyl ether	methyl isobutyl ketone
n-butyl alcohol	cyclohexanone

- **F004** Code - spent solvent mixtures and blends. Contain before use, a total of 10% or more (by volume) of one or more of the following non-halogenated solvents:
 - cresols and cresylic acid
 - nitrobenzene

- **F005** Code - spent solvent mixtures and blends. Contain before use, a total of 10% or more (by volume) of one or more of the following non-halogenated solvents:

toluene	methyl ethyl ketone
carbon disulfide	isobutanol
pyridine	benzene
2-ethoxyethanol	2-nitropropane

CHEMICAL HYGIENE PLAN

APPENDIX O: CONTINUED

K List - contains waste from specific sources such as factories or industries which by definition is not generally applicable to wastes generated by clinical laboratories.

P List - covers acutely hazardous wastes (AHW). Criteria for this list are as follows:

- Small doses cause human mortality.
- Oral $LD_{50} = < 50$ ppm by weight (mg/Kg).
- Inhalation $LC_{50} = < 2$ mg/L.
- Dermal $LD_{50} = < 200$ mg/Kg.

The list may not be applicable to chemicals used by your facility.

Examples - nickel tetracarbonyl, phosphine, and osmium tetroxide.

U List - addresses used and unused hazardous materials that are toxic.

Examples - aniline, benzene, and acetone.

CHEMICAL HYGIENE PLAN

APPENDIX P

EPA UNIFORM HAZARDOUS WASTE MANIFEST

Please print or type. (Form designed for use on elite (12-pitch) typewriter.) Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST		1. Generator ID Number		2. Page 1 of		3. Emergency Response Phone		4. Manifest Tracking Number		
		5. Generator's Name and Mailing Address					Generator's Site Address (if different than mailing address)			
Generator's Phone:										
6. Transporter 1 Company Name					U.S. EPA ID Number					
7. Transporter 2 Company Name					U.S. EPA ID Number					
8. Designated Facility Name and Site Address					U.S. EPA ID Number					
Facility's Phone:										
GENERATOR	9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))			10. Containers		11. Total	12. Unit	13. Waste Codes	
			No.	Type	Quantity	WT./Vol.				
	1.									
	2.									
	3.									
14. Special Handling Instructions and Additional Information										
15. GENERATOR'S/OFFEROR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent. I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.										
Generator's/Offeror's Printed/Typed Name					Signature			Month	Day	Year
16. International Shipments <input type="checkbox"/> Import to U.S. <input type="checkbox"/> Export from U.S. Port of entry/exit: _____ Date leaving U.S.: _____										
17. Transporter Acknowledgment of Receipt of Materials										
Transporter 1 Printed/Typed Name					Signature			Month	Day	Year
Transporter 2 Printed/Typed Name					Signature			Month	Day	Year
18. Discrepancy										
18a. Discrepancy Indication Space <input type="checkbox"/> Quantity <input type="checkbox"/> Type <input type="checkbox"/> Residue <input type="checkbox"/> Partial Rejection <input type="checkbox"/> Full Rejection										
18b. Alternate Facility (or Generator)					Manifest Reference Number:			U.S. EPA ID Number		
Facility's Phone:										
18c. Signature of Alternate Facility (or Generator)					Signature			Month	Day	Year
19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)										
1.	2.	3.	4.							
20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a										
Printed/Typed Name					Signature			Month	Day	Year

Source: EPA

APPENDIX Q

29CFR PART 1910 - OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Subpart Z - Toxic and Hazardous Substances

TABLE Z-1 Limits for Air Contaminants.

NOTE: Because of the length of the table, explanatory Footnotes applicable to all substances are given below as well as at the end of the table. Footnotes specific only to a limited number of substances are also shown within the table.

- Footnote (1) The PELs are 8-hour TWAs unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.
- Footnote (a) Parts of vapor or gas per million parts of contaminated air by volume at 25 degrees C and 760 torr.
- Footnote (b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.
- Footnote (c) The CAS number is for information only. Enforcement is based on the substance name. For an entry covering more than one metal compound measured as the metal, the CAS number for the metal is given - not CAS numbers for the individual compounds.
- Footnote (d) The final benzene standard in 1910.1028 applies to all occupational exposures to benzene except in some circumstances the distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures; for the excepted subsegments, the benzene limits in Table Z-2 apply. See 1910.1028 for specific circumstances.
- Footnote (e) This 8-hour TWA applies to respirable dust as measured by a vertical elutriator cotton dust sampler or equivalent instrument. The time-weighted average applies to the cotton waste processing operations of waste recycling (sorting, blending, cleaning and willowing) and garmetting. See also 1910.1043 for cotton dust limits applicable to other sectors.
- Footnote (f) All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by the Particulates Not Otherwise Regulated (PNOR) limit which is the same as the inert or nuisance dust limit of Table Z-3.
- Footnote (2) See Table Z-2.
- Footnote (3) See Table Z-3
- Footnote (4) Varies with compound.

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Acetaldehyde	75-07-0	200	360	
Acetic acid	64-19-7	10	25	
Acetic anhydride	108-24-7	5	20	
Acetone	67-64-1	1000	2400	
Acetonitrile	75-05-8	40	70	
2-Acetylaminofluorene; see 1910.1014	53-96-3			
Acetylene dichloride; see 1,2-Dichloroethylene				
Acetylene tetrabromide	79-27-6	1	14	
Acrolein	107-02-8	0.1	0.25	
Acrylamide	79-06-1		0.3	X
Acrylonitrile; see 1910.1045	107-13-1			
Aldrin	309-00-2		0.25	X

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Allyl alcohol	107-18-6	2	5	X
Allyl chloride	107-05-1	1	3	
Allyl glycidyl ether (AGE)	106-92-3	(C)10	(C)45	
Allyl propyl disulfide	2179-59-1	2	12	
alpha-Alumina	1344-28-1			
Total dust			15	
Respirable fraction			5	
Aluminum Metal (as Al)	7429-90-5			
Total dust			15	
Respirable fraction			5	
4-Aminodiphenyl; see 1910.1011	92-67-1			
2-Aminoethanol; see Ethanolamine				
2-Aminopyridine	504-29-0	0.5	2	
Ammonia	7664-41-7	50	35	
Ammonium sulfamate	7773-06-0			
Total dust			15	
Respirable fraction			5	
n-Amyl acetate	628-63-7	100	525	
sec-Amyl acetate	626-38-0	125	650	
Aniline and homologs	62-53-3	5	19	X
Anisidine (o-,p-isomers)	29191-52-4		0.5	X
Antimony and compounds (as Sb)	7440-36-0		0.5	
ANTU (alpha Naphthylthiourea)	86-88-4		0.3	
Arsenic, inorganic compounds (as As); see 1910.1018	7440-38-2			
Arsenic, organic compounds (as As)	7440-38-2		0.5	
Arsine	7784-42-1	0.05	0.2	
Asbestos; see 1910.1001			(4)	
Azinphos-methyl	86-50-0		0.2	X
Barium, soluble compounds (as Ba)	7440-39-3		0.5	
Barium sulfate	7727-43-7			
Total dust			15	
Respirable fraction			5	
Benomyl	17804-35-2			
Total dust			15	
Respirable fraction			5	
Benzene; See 1910.1028 See Table Z-2 for the limits applicable in the operations or sectors excluded in 1910.1028	71-43-2			
Benzidine; See 1910.1010	92-87-5			
p-Benzoquinone; see Quinone.				
Benzo(a)pyrene; see Coal tar pitch volatiles				
Benzoyl peroxide	94-36-0		5	
Benzyl chloride	100-44-7	1	5	
Beryllium and beryllium compounds (as Be)	7440-41-7		(2)	
Biphenyl; see Diphenyl				

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Bismuth telluride, Undoped	1304-82-1			
Total dust			15	
Respirable fraction			5	
Boron oxide	1303-86-2			
Total dust			15	
Boron trifluoride	7637-07-2	(C)1	(C)3	
Bromine	7726-95-6	0.1	0.7	
Bromoform	75-25-2	0.5	5	X
Butadiene (1,3-Butadiene)	106-99-0	1000	2200	
Butanethiol; see Butyl mercaptan				
2-Butanone (Methyl ethyl ketone)	78-93-3	200	590	
2-Butoxyethanol	111-76-2	50	240	X
n-Butyl-acetate	123-86-4	150	710	
sec-Butyl acetate	105-46-4	200	950	
tert-Butyl-acetate	540-88-5	200	950	
n-Butyl alcohol	71-36-3	100	300	
sec-Butyl alcohol	78-92-2	150	450	
tert-Butyl alcohol	75-65-0	100	300	
Butylamine	109-73-9	(C)5	(C)15	X
tert-Butyl chromate (as CrO(3))	1189-85-1		(C)0.1	X
n-Butyl glycidyl ether (BGE)	2426-08-6	50	270	
Butyl mercaptan	109-79-5	10	35	
p-tert-Butyltoluene	98-51-1	10	60	
Cadmium (as Cd); see 1910.1027	7440-43-9			
Calcium Carbonate	1317-65-3			
Total dust			15	
Respirable fraction			5	
Calcium hydroxide	1305-62-0			
Total dust			15	
Respirable fraction			5	
Calcium oxide	1305-78-8		5	
Calcium silicate				1344-95-2
Total dust			15	
Respirable fraction			5	
Calcium sulfate	7778-18-9			
Total dust			15	
Respirable fraction			5	
Camphor, synthetic	76-22-2		2	
Carbaryl (Sevin)	63-25-2		5	
Carbon black	1333-86-4		3.5	
Carbon dioxide	124-38-9	5000	9000	
Carbon disulfide	75-15-0		(2)	
Carbon monoxide	630-08-0	50	55	
Carbon tetrachloride	56-23-5		(2)	
Cellulose	9004-34-6			
Total dust			15	
Respirable fraction			5	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Chlordane	57-74-9		0.5	X
Chlorinated camphene	8001-35-2		0.5	X
Chlorinated diphenyl oxide	55720-99-5		0.5	
Chlorine	7782-50-5	(C)1	(C)3	
Chlorine dioxide	10049-04-4	0.1	0.3	
Chlorine trifluoride	7790-91-2	(C)0.1	(C)0.4	
Chloroacetaldehyde	107-20-0	(C)1	(C)3	
a-Chloroacetophenone (Phenacyl chloride)	532-27-4	0.05	0.3	
Chlorobenzene	108-90-7	75	350	
o-Chlorobenzylidene malononitrile	2698-41-1	0.05	0.4	
Chlorobromomethane	74-97-5	200	1050	
2-Chloro-1,3-butadiene; See beta-Chloroprene				
Chlorodiphenyl (42% Chlorine)(PCB)	53469-21-9		1	X
Chlorodiphenyl (54% Chlorine)(PCB)	11097-69-1		0.5	X
1-Chloro-2, 3-epoxypropane; See Epichlorohydrin				
2-Chloroethanol; See Ethylene chlorohydrin				
Chloroethylene; See Vinyl chloride				
Chloroform (Trichloromethane)	67-66-3	(C)50	(C)240	
bis(Chloromethyl) ether; see 1910.1008	542-88-1			
Chloromethyl methyl ether; see 1910.1006	107-30-2			
1-Chloro-1-nitropropane	600-25-9	20	100	
Chloropicrin	76-06-2	0.1	0.7	
beta-Chloroprene	126-99-8	25	90	X
2-Chloro-6 (trichloromethyl) pyridine	1929-82-4			
Total dust			15	
Respirable fraction			5	
Chromic acid and chromates (as CrO(3))	(4)		(2)	
Chromium (II) compounds (as Cr)	7440-47-3		0.5	
Chromium (III) compounds (as Cr)	7440-47-3		0.5	
Chromium metal and insol. salts (as Cr)	7440-47-3		1	
Chrysene; see Coal tar pitch volatiles				
Clopidol	2971-90-6			
Total dust			15	
Respirable fraction			5	
Coal dust (less than 5% SiO(2)), respirable fraction			(3)	
Coal dust (greater than or equal to 5% SiO(2)), respirable fraction			(3)	
Coal tar pitch volatiles (benzene soluble fraction), anthracene, BaP, phenanthrene, acridine, chrysene, pyrene	65966-93-2		0.2	
Cobalt metal, dust, and fume (as Co)	7440-48-4		0.1	
Coke oven emissions; see 1910.1029				

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Copper	7440-50-8			
Fume (as Cu)			0.1	
Dusts and mists (as Cu)			1	
Cotton dust (e), see 1910.1043			1	
Crag herbicide (Sesone)	136-78-7			
Total dust			15	
Respirable fraction			5	
Cresol, all isomers	1319-77-3	5	22	X
Crotonaldehyde	123-73-9	2	6	
	4170-30-3			
Cumene	98-82-8	50	245	X
Cyanides (as CN)	(4)		5	
Cyclohexane	110-82-7	300	1050	
Cyclohexanol	108-93-0	50	200	
Cyclohexanone	108-94-1	50	200	
Cyclohexene	110-83-8	300	1015	
Cyclopentadiene	542-92-7	75	200	
2,4-D (Dichlorophenoxyacetic acid)	94-75-7		10	
Decaborane	17702-41-9	0.05	0.3	X
Demeton (Systox)	8065-48-3		0.1	X
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)	123-42-2	50	240	
1,2-Diaminoethane; see Ethylenediamine				
Diazomethane	334-88-3	0.2	0.4	
Diborane	19287-45-7	0.1	0.1	
1,2-Dibromo-3-chloropropane (CBCP); see 1910.1044	96-12-8			
1,2-Dibromoethane; see Ethylene dibromide				
Dibutyl phosphate	107-66-4	1	5	
Dibutyl phthalate	84-74-2		5	
o-Dichlorobenzene	95-50-1	(C)50	(C)300	
p-Dichlorobenzene	106-46-7	75	450	
3,3'-Dichlorobenzidine; see 1910.1007	91-94-1			
Dichlorodifluoromethane	75-71-8	1000	4950	
1,3-Dichloro-5, 5-dimethyl hydantoin	118-52-5		0.2	
Dichlorodiphenyltrichloroethane (DDT)	50-29-3		1	X
1,1-Dichloroethane	75-34-3	100	400	
1,2-Dichloroethane; see Ethylene dichloride				
1,2-Dichloroethylene	540-59-0	200	790	
Dichloroethyl ether	111-44-4	(C)15	(C)90	X
Dichloromethane; see Methylene chloride				
Dichloromonofluoromethane	75-43-4	1000	4200	
1,1-Dichloro-1-nitroethane	594-72-9	(C)10	(C)60	
1,2-Dichloropropane; see Propylene dichloride				
Dichlorotetrafluoroethane	76-14-2	1000	7000	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Dichlorvos (DDVP)	62-73-7		1	X
Dicyclopentadienyl iron	102-54-5			
Total dust			15	
Respirable fraction			5	
Dieldrin	60-57-1		0.25	X
Diethylamine	109-89-7	25	75	
2-Diethylaminoethanol	100-37-8	10	50	X
Diethyl ether; see Ethyl ether				
Difluorodibromomethane	75-61-6	100	860	
Diglycidyl ether (DGE)	2238-07-5	(C)0.5	(C)2.8	
Dihydroxybenzene; see Hydroquinone				
Diisobutyl ketone	108-83-8	50	290	
Diisopropylamine	108-18-9	5	20	X
4-Dimethylaminoazobenzene; see 1910.1015	60-11-7			
Dimethoxymethane; see Methylal				
Dimethyl acetamide	127-19-5	10	35	X
Dimethylamine	124-40-3	10	18	
Dimethylaminobenzene; see Xylidine				
Dimethylaniline (N,N-Dimethylaniline)	121-69-7	5	25	X
Dimethylbenzene; see Xylene				
Dimethyl-1,2-dibromo-2,2-dichloroethylphosphate	300-76-5		3	
Dimethylformamide	68-12-2	10	30	X
2,6-Dimethyl-4-heptanone; see Diisobutyl ketone				
1,1-Dimethylhydrazine	57-14-7	0.5	1	X
Dimethylphthalate	131-11-3		5	
Dimethyl sulfate	77-78-1	1	5	X
Dinitrobenzene (all isomers)			1	X
(ortho)	528-29-0			
(meta)	99-65-0			
Dinitro-o-cresol	534-52-1		0.2	X
Dinitrotoluene	25321-14-6		1.5	X
Dioxane (Diethylene dioxide)	123-91-1	100	360	X
Diphenyl (Biphenyl)	92-52-4	0.2	1	
Diphenylmethane diisocyanate; see Methylene bisphenyl isocyanate				
Dipropylene glycol methyl ether	34590-94-8	100	600	X
Di-sec octyl phthalate (Di-(2-ethylhexyl) phthalate)	117-81-7		5	
Emery	12415-34-8			
Total dust			15	
Respirable fraction			5	
Endosulfan	115-29-7		0.1	X
Endrin	72-20-8		0.1	X
Epichlorohydrin	106-89-8	5	19	X

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
EPN	2104-64-5		0.5	X
1,2-Epoxypropane; see Propylene oxide				
2,3-Epoxy-1-propanol; see Glycidol				
Ethanethiol; see Ethyl mercaptan				
Ethanolamine	141-43-5	3	6	
2-Ethoxyethanol (Cellosolve)	110-80-5	200	740	X
2-Ethoxyethyl acetate (Cellosolve acetate)	111-15-9	100	540	X
Ethyl acetate	141-78-6	400	1400	
Ethyl acrylate	140-88-5	25	100	X
Ethyl alcohol (Ethanol)	64-17-5	1000	1900	
Ethylamine	75-04-7	10	18	
Ethyl amyl ketone (5-Methyl-3-heptanone)	541-85-5	25	130	
Ethyl benzene	100-41-4	100	435	
Ethyl bromide	74-96-4	200	890	
Ethyl butyl ketone (3-Heptanone)	106-35-4	50	230	
Ethyl chloride	75-00-3	1000	2600	
Ethyl ether	60-29-7	400	1200	
Ethyl formate	109-94-4	100	300	
Ethyl mercaptan	75-08-1	(C)10	(C)25	
Ethyl silicate	78-10-4	100	850	
Ethylene chlorohydrin	107-07-3	5	16	X
Ethylenediamine	107-15-3	10	25	
Ethylene dibromide	106-93-4		(2)	
Ethylene dichloride (1,2-Dichloroethane)	107-06-2		(2)	
Ethylene glycol dinitrate	628-96-6	(C)0.2	(C)1	X
Ethylene glycol methyl acetate; see Methyl cellosolve acetate				
Ethyleneimine; See 1910.1012				
Ethylene oxide; see 1910.1047	75-21-8			
Ethylidene chloride; see 1,1-Dichloroethane				
N-Ethylmorpholine	100-74-3	20	94	X
Ferbam	14484-64-1			
Total dust			15	
Ferrovandium dust	12604-58-9		1	
Fluorides (as F)	(4)		2.5	
Fluorine	7782-41-4	0.1	0.2	
Fluorotrichloromethane (Trichloro-fluoromethane)	75-69-4	1000	5600	
Formaldehyde; see 1910.1048	50-00-0			
Formic acid	64-18-6	5	9	
Furfural	98-01-1	5	20	X
Furfuryl alcohol	98-00-0	50	200	
Grain dust (oat, wheat, barley)			10	
Glycerin (mist)	56-81-5			
Total dust			15	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Respirable fraction			5	
Glycidol	556-52-5	50	150	
Glycol monoethyl ether; see 2-Ethoxyethanol				
Graphite, natural respirable dust	7782-42-5		(3)	
Graphite, synthetic				
Total dust			15	
Respirable Fraction			5	
Guthion; see Azinphos methyl				
Gypsum	13397-24-5			
Total dust			15	
Respirable fraction			5	
Hafnium	7440-58-6		0.5	
Heptachlor	76-44-8		0.5	X
Heptane (n-Heptane)	142-82-5	500	2000	
Hexachloroethane	67-72-1	1	10	X
Hexachloronaphthalene	1335-87-1		0.2	X
n-Hexane	110-54-3	500		1800
2-Hexanone (Methyl n-butyl ketone)	591-78-6	100	410	
Hexone (Methyl isobutyl ketone)	108-10-1	100	410	
sec-Hexyl acetate	108-84-9	50	300	
Hydrazine	302-01-2	1	1.3	X
Hydrogen bromide	10035-10-6	3	10	
Hydrogen chloride	7647-01-0	(C)5	(C)7	
Hydrogen cyanide	74-90-8	10	11	X
Hydrogen fluoride (as F)	7664-39-3		(2)	
Hydrogen peroxide	7722-84-1	1	1.4	
Hydrogen selenide (as Se)	7783-07-5	0.05	0.2	
Hydrogen sulfide	7783-06-4		(2)	
Hydroquinone	123-31-9		2	
Iodine	7553-56-2	(C)0.1	(C)1	
Iron oxide fume	1309-37-1		10	
Isomyl acetate	123-92-2	100	525	
Isomyl alcohol (primary and secondary)	123-51-3	100	360	
Isobutyl acetate	110-19-0	150	700	
Isobutyl alcohol	78-83-1	100	300	
Isophorone	78-59-1	25	140	
Isopropyl acetate	108-21-4	250	950	
Isopropyl alcohol	67-63-0	400	980	
Isopropylamine	75-31-0	5	12	
Isopropyl ether	108-20-3	500	2100	
Isopropyl glycidyl ether (IGE)	4016-14-2	50	240	
Kaolin	1332-58-7			
Total dust			15	
Respirable fraction			5	
Ketene	463-51-4	0.5	0.9	
Lead inorganic (as Pb); see 1910.1025	7439-92-1			

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Limestone	1317-65-3			
Total dust			15	
Respirable fraction			5	
Lindane	58-89-9		0.5	X
Lithium hydride	7580-67-8		0.025	
L.P.G. (Liquified petroleum gas)	68476-85-7	1000	1800	
Magnesite	546-93-0			
Total dust			15	
Respirable fraction			5	
Magnesium oxide fume	1309-48-4			
Total Particulate			15	
Malathion	121-75-5		15	X
Total dust				
Maleic anhydride	108-31-6	0.25	1	
Manganese compounds (as Mn)	7439-96-5		(C)5	
Manganese fume (as Mn)	7439-96-5		(C)5	
Marble	1317-65-3			
Total dust			15	
Respirable fraction			5	
Mercury (aryl and inorganic)(as Hg)	7439-97-6		(2)	
Mercury (organo) alkyl compounds (as Hg)	7439-97-6		(2)	
Mercury (vapor) (as Hg)	7439-97-6		(2)	
Mesityl oxide	141-79-7	25	100	
Methanethiol; see Methyl mercaptan				
Methoxychlor	72-43-5			
Total dust			15	
2-Methoxyethanol; (Methyl cellosolve)	109-86-4	25	80	X
2- Methoxyethyl acetate (Methyl cellosolve acetate)	110-49-6	25	120	X
Methyl acetate	79-20-9	200	610	
Methyl acetylene (Propyne)	74-99-7	1000	1650	
Methyl acetylene propadiene mixture (MAPP)		1000	1800	
Methyl acrylate	96-33-3	10	35	X
Methylal (Dimethoxy-methane)	109-87-5	1000	3100	
Methyl alcohol	67-56-1	200	260	
Methylamine	74-89-5	10	12	
Methyl amyl alcohol; see Methyl Isobutyl carbinol				
Methyl n-amyl ketone	110-43-0	100	465	
Methyl bromide	74-83-9	(C)20	(C)80	X
Methyl butyl ketone; see 2-Hexanone				
Methyl cellosolve; see 2-Methoxyethanol				
Methyl cellosolve acetate; see 2-Methoxyethyl acetate				
Methyl chloride	74-87-3		(2)	
Methyl chloroform (1,1,1-Trichloro-ethane)	71-55-6	350	1900	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Methylcyclohexane	108-87-2	500	2000	
Methylcyclohexanol	25639-42-3	100	470	
o-Methylcyclohexanone	583-60-8	100	460	X
Methylene chloride	75-09-2		(2)	
Methyl ethyl ketone (MEK); see 2-Butanone				
Methyl formate	107-31-3	100	250	
Methyl hydrazine (Monomethyl hydrazine)	60-34-4	(C)0.2	(C)0.35	X
Methyl iodide	74-88-4	5	28	X
Methyl isoamyl ketone	110-12-3	100	475	
Methyl isobutyl carbinol	108-11-2	25	100	X
Methyl isobutyl ketone; see Hexone				
Methyl isocyanate	624-83-9	0.02	0.05	X
Methyl mercaptan	74-93-1	(C)10	(C)20	
Methyl methacrylate	80-62-6	100	410	
Methyl propyl ketone; see 2-Pentanone				
alpha-Methyl styrene	98-83-9	(C)100	(C)480	
Methylene bisphenyl isocyanate (MDI)	101-68-8	(C)0.02	(C)0.2	
Mica; see Silicates				
Molybdenum (as Mo)	7439-98-7			
Soluble compounds			5	
Insoluble Compounds				
Total dust			15	
Monomethyl aniline	100-61-8	2	9	X
Monomethyl hydrazine; see Methyl hydrazine				
Morpholine	110-91-8	20	70	X
Naphtha (Coal tar)	8030-30-6	100	400	
Naphthalene	91-20-3	10	50	
alpha-Naphthylamine; see 1910.1004	134-32-7			
beta-Naphthylamine; see 1910.1009	91-59-8			
Nickel carbonyl (as Ni)	13463-39-3	0.001	0.007	
Nickel, metal and insoluble compounds (as Ni)	7440-02-0		1	
Nickel, soluble compounds (as Ni)	7440-02-0		1	
Nicotine	54-11-5		0.5	X
Nitric acid	7697-37-2	2	5	
Nitric oxide	10102-43-9	25	30	
p-Nitroaniline	100-01-6	1	6	X
Nitrobenzene	98-95-3	1	5	X
p-Nitrochlorobenzene	100-00-5		1	X
4-Nitrodiphenyl; see 1910.1003	92-93-3			
Nitroethane	79-24-3	100	310	
Nitrogen dioxide	10102-44-0	(C)5	(C)9	
Nitrogen trifluoride	7783-54-2	10	29	
Nitroglycerin	55-63-0	(C)0.2	(C)2	X
Nitromethane	75-52-5	100	250	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
1-Nitropropane	108-03-2	25	90	
2-Nitropropane	79-46-9	25	90	
N-Nitrosodimethylamine; see 1910.1016				
Nitrotoluene (all isomers)		5	30	X
o-isomer	88-72-2			
m-isomer	99-08-1			
p-isomer				
Nitrotrichloromethane; see Chloropicrin				
Octachloronaphthalene	2234-13-1		0.1	X
Octane	111-65-9	500	2350	
Oil mist, mineral	8012-95-1		5	
Osmium tetroxide (as Os)	20816-12-0		0.002	
Oxalic acid	144-62-7		1	
Oxygen difluoride	7783-41-7	0.05	0.1	
Ozone	10028-15-6	0.1	0.2	
Paraquat, respirable dust	4685-14-7		0.5	X
	1910-42-5			
	2074-50-2			
Parathion	56-38-2		0.1	X
Particulates not otherwise regulated (PNOR)(f)				
Total dust			15	
Respirable fraction			5	
PCB; see Chlorodiphenyl (42% and 54% chlorine)				
Pentaborane	19624-22-7	0.005	0.01	
Pentachloronaphthalene	1321-64-8		0.5	X
Pentachlorophenol	87-86-5		0.5	X
Pentaerythritol	115-77-5			
Total dust			15	
Respirable fraction			5	
Pentane	109-66-0	1000	2950	
2-Pentanone (Methyl propyl ketone)	107-87-9	200	700	
Perchloroethylene (Tetrachloroethylene)	127-18-4		(2)	
Perchloromethyl mercaptan	594-42-3	0.1	0.8	
Perchloryl fluoride	7616-94-6	3	13.5	
Perlite	93763-70-3			
Total dust			15	
Respirable fraction			5	
Petroleum distillates (Naphtha)(Rubber Solvent)		500	2000	
Phenol	108-95-2	5	19	X
p-Phenylene diamine	106-50-3		0.1	X
Phenyl ether, vapor	101-84-8	1	7	
Phenyl ether-biphenyl mixture, vapor		1	7	
Phenylethylene; see Styrene				
Phenyl glycidyl ether (PGE)	122-60-1	10	60	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Phenylhydrazine	100-63-0	5	22	X
Phosdrin (Mevinphos)	7786-34-7		0.1	X
Phosgene (Carbonyl chloride)	75-44-5	0.1	0.4	
Phosphine	7803-51-2	0.3	0.4	
Phosphoric acid	7664-38-2		1	
Phosphorus (yellow)	7723-14-0		0.1	
Phosphorus pentachloride	10026-13-8		1	
Phosphorus pentasulfide	1314-80-3		1	
Phosphorus trichloride	7719-12-2	0.5	3	
Phthalic anhydride	85-44-9	2	12	
Picloram	1918-02-1			
Total dust			15	
Respirable fraction			5	
Picric acid	88-89-1		0.1	X
Pindone (2-Pivalyl-1,3-indandione)	83-26-1		0.1	
Plaster of paris	26499-65-0			
Total dust			15	
Respirable fraction			5	
Platinum (as Pt) Metal Soluble Salts	7440-06-4		0.002	
Portland cement	65997-15-1			
Total dust			15	
Respirable fraction			5	
Propane	74-98-6	1000	1800	
beta-Propriolactone; see 1910.1013	57-57-8			
n-Propyl acetate	109-60-4	200	840	
n-Propyl alcohol	71-23-8	200	500	
n-Propyl nitrate	627-13-4	25	110	
Propylene dichloride	78-87-5	75	350	
Propylene imine	75-55-8	2	5	X
Propylene oxide	75-56-9	100	240	
Propyne; see Methyl acetylene				
Pyrethrum	8003-34-7		5	
Pyridine	110-86-1	5	15	
Quinone	106-51-4	0.1	0.4	
RDX: see Cyclonite				
Rhodium (as Rh), metal fume and insoluble compounds	7440-16-6		0.1	
Rhodium (as Rh), soluble compounds	7440-16-6		0.001	
Ronnel	299-84-3		15	
Rotenone	83-79-4		5	
Rouge				
Total dust			15	
Respirable fraction			5	
Selenium compounds (as Se)	7782-49-2		0.2	
Selenium hexafluoride (as Se)	7783-79-1	0.05	0.4	
Silica, amorphous, precipitated and gel	112926-00-8		(3)	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Silica, amorphous, diatomaceous earth, containing less than 1% crystalline silica	61790-53-2		(3)	
Silica, crystalline cristobalite, respirable dust	14464-46-1		(3)	
Silica, crystalline quartz, respirable dust	14808-60-7		(3)	
Silica, crystalline tripoli (as quartz), respirable dust	1317-95-9		(3)	
Silica, crystalline tridymite, respirable dust	15468-32-3		(3)	
Silica, fused, respirable dust	60676-86-0		(3)	
Silicates (less than 1% crystalline silica)				
Mica (respirable dust)	12001-26-2		(3)	
Soapstone, total dust			(3)	
Soapstone, respirable dust			(3)	
Talc (containing asbestos): use asbestos limit: see 29 CFR 1910.1001			(3)	
Talc (containing no asbestos), respirable dust Tremolite, asbestiform; see 1910.1001	14807-96-6		(3)	
Silicon	7440-21-3			
Total dust			15	
Respirable fraction			5	
Silicon carbide	409-21-2			
Total dust			15	
Respirable fraction			5	
Silver, metal and soluble compounds (as Ag)	7440-22-4		0.01	
Soapstone; see Silicates				
Sodium fluoroacetate	62-74-8		0.05	X
Sodium hydroxide	1310-73-2		2	
Starch	9005-25-8			
Total dust			15	
Respirable fraction			5	
Stibine	7803-52-3	0.1	0.5	
Stoddard solvent	8052-41-3	500	2900	
Strychnine	57-24-9		0.15	
Styrene	100-42-5		(2)	
Sucrose	57-50-1			
Total dust			15	
Respirable fraction			5	
Sulfur dioxide	7446-09-5	5	13	
Sulfur hexafluoride	2551-62-4	1000	6000	
Sulfuric acid	7664-93-9		1	
Sulfur monochloride	10025-67-9	1	6	
Sulfur pentafluoride	5714-22-7	0.025	0.25	
Sulfuryl fluoride	2699-79-8	5	20	
Systox; see Demeton				
2,4,5-T (2,4,5-tri-chlorophenoxyacetic acid)	93-76-5		10	
Talc; see Silicates				
Tantalum, metal and oxide dust	7440-25-7		5	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
TEDP (Sulfotep)	3689-24-5		0.2	X
Tellurium and compounds (as Te)	13494-80-9		0.1	
Tellurium hexafluoride (as Te)	7783-80-4	0.02	0.2	
Temephos	3383-96-8			
Total dust			15	
Respirable fraction			5	
TEPP (Tetraethyl pyrophosphaate)	107-49-3		0.05	X
Terphenylis	26140-60-3	(C)1	(C)9	
1,1,1,2-Tetrachloro-2,2-difluoroethane	76-11-9	500	4170	
1,1,2,2-Tetrachloro-1,2-difluoroethane	76-12-0	500	4170	
1,1,2,2-Tetrachloro-ethane	79-34-5	5	35	X
Tetrachoroethylene; see Perchloroethylene				
Tetrachloromethane; see Carbon tetrachloride				
Tetrachloronaphthalene	1335-88-2		2	X
Tetraethyl lead (as Pb)	78-00-2		0.075	X
Tetrahydrofuran	109-99-9	200	590	
Tetramethyl lead, (as Pb)	75-74-1		0.075	X
Tetramethyl succinonitrile	3333-52-6	0.5	3	X
Tetranitromethane	509-14-8	1	8	
Tetryl (2,4,6-Trinitro-phenylmethyl-nitramine)	479-45-8		1.5	X
Thallium, soluble compounds (as Tl)	7440-28-0		0.1	X
4,4'-Thiobis (6-tert, Butyl-m-cresol)	96-69-5			
Total dust			15	
Respirable fraction			5	
Thiram	137-26-8		5	
Tin, inorganic compounds (except oxides) (as Sn)	7440-31-5		2	
Tin, organic compounds (as Sn)	7440-31-5		0.1	
Titanium dioxide	13463-67-7			
Total dust			15	
Toluene	108-88-3		(2)	
Toluene-2,4-diisocyanate (TDI)	584-84-9	(C)0.02	(C)0.14	
o-Toluidine	95-53-4	5	22	X
Toxaphene; see Chlorinated camphene				
Tremolite; see Silicates				
Tributyl phosphate	126-73-8		5	
1,1,1-Trichloroethane; see Methyl chloroform				
1,1,2-Trichloroethane	79-00-5	10	45	X
Trichloroethylene	79-01-6		(2)	
Trichloromethane; see Chloroform				
Trichloronaphthalene	1321-65-9		5	X
1,2,3-Trichloropropane	96-18-4	50	300	
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	1000	7600	

CHEMICAL HYGIENE PLAN

Substance	CAS No. (c)	ppm (a)(1)	mg/m ³ (b)(1)	Skin designation
Triethylamine	121-44-8	25	100	
Trifluorobromomethane	75-63-8	1000	6100	
2,4,6-Trinitrophenyl; see Picric acid				
2,4,6-Trinitrophenyl-methyl nitramine; see Tetryl				
2,4,6-Trinitrotoluene (TNT)	118-96-7		1.5	X
Triorthocresyl phosphate	78-30-8		0.1	
Triphenyl phosphate	115-86-6		3	
Turpentine	8006-64-2	100	560	
Uranium (as U)	7440-61-1			
Soluble compounds			0.05	
Insoluble compounds			0.05	
Vanadium	1314-62-1			
Respirable dust (as V(2)O(5))			(C)0.5	
Fume (as V(2)O(5))			(C)0.1	
Vegetable oil mist				
Total dust			15	
Respirable fraction			5	
Vinyl benzene; see Styrene				
Vinyl chloride; see 1910.1017	75-01-4			
Vinyl cyanide; see Acrylonitrile				
Vinyl toluene	25013-15-4	100	480	
Warfarin	81-81-2		0.1	
Xylenes (o-, m-, p-isomers)	1330-20-7	100	435	
Xylidine	1300-73-8	5	25	X
Yttrium	7440-65-5		1	
Zinc chloride fume	7646-85-7		1	
Zinc oxide fume	1314-13-2		5	
Zinc oxide	1314-13-2			
Total dust			15	
Respirable fraction			5	
Zinc stearate	557-05-1			
Total dust			15	
Respirable fraction			5	
Zirconium compounds (as Zr)	7440-67-7		5	

APPENDIX R

TABLE Z-2 Limits for Air Contaminants

Substance	8-hour time weighted average	Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift	
			Concentration	Maximum duration
Benzene ^(a) (Z37.40-1969)	10 ppm	25 ppm	50 ppm	10 minutes.
Beryllium and beryllium compounds (Z37.29-1970)	2 ug/m(3)	5 ug/m(3)	25 ug/m(3)	30 minutes.
Cadmium fume ^(b) (Z37.5-1970)	0.1 mg/m(3)	0.3 mg/m(3)	.....
Cadmium dust ^(b) (Z37.5-1970)	0.2 mg/m(3)	0.6 mg/m(3)		
Carbon disulfide (Z37.3-1968)	20 ppm	30 ppm	100 ppm	30 minutes.
Carbon tetrachloride (Z37.17-1967)	10 ppm	25 ppm	200 ppm	5 min. in any 3 hrs.
Chromic acid and chromates (Z37-7-1971) ^(c)	.....	1 mg/10 m(3)		
Ethylene dibromide (Z37.31-1970)	20 ppm	30 ppm	50 ppm	5 minutes.
Ethylene dichloride (Z37.21-1969)	50 ppm	100 ppm	200 ppm	5 min. in any 3 hrs.
Fluoride as dust (Z37.28-1969)	2.5 mg/m(3)	.....	.....
Formaldehyde: see 1910.1048	.....	.....	.....
Hydrogen fluoride (Z37.28-1969)	3 ppm	.....	.....
Hydrogen sulfide (Z37.2-1966)	.....	20 ppm	50 ppm	10 mins. once only if no other meas. exp. occurs.
Mercury (Z37.8-1971)	.....	1 mg/10m(3)	.....
Methyl chloride (Z37.18-1969)	100 ppm	200 ppm	300 ppm	5 mins. in any 3 hrs.
Methylene Chloride: see 1910.1052				
Organo (alkyl) mercury (Z37.30-1969)	0.01mg/m(3)	0.04 mg/m(3)	.....
Styrene (Z37.15-1969)	100 ppm	200 ppm	600 ppm	5 mins. in any 3 hrs.
Tetrachloroethylene	100 ppm	200 ppm	300 ppm	5 mins. in any 3 hrs.
Toluene (Z37.12-1967)	200 ppm	300 ppm	500 ppm	10 minutes
Trichloroethylene (Z37.19-1967)	100 ppm	200 ppm	300 ppm	5 mins. in any 2 hrs.

Footnote^(a) This standard applies to the industry segments exempt from the 1 ppm 8-hour TWA and 5 ppm STEL of the benzene standard at 1910.1028.

Footnote^(b) This standard applies to any operations or sectors for which the Cadmium standard, 1910.1027, is stayed or otherwise not in effect.

Footnote^(c) Footnote(c) This standard applies to any operations or sectors for which the exposures limit in the Chromium (VI) standard, Sec. 1910.1026, is stayed or is otherwise not in effect.

APPENDIX S

TABLE Z-3 Mineral Dusts

Substance	mppcf ^a	mg/m ³
Silica:		
Crystalline		
Quartz (Respirable)	$\frac{250^b}{\%SiO_2+5}$	$\frac{10 \text{ mg/m}^3 \text{ }^e}{\%SiO_2+2}$
Quartz (Total Dust) . . . . .	.....	$\frac{30 \text{ mg/m}^3}{\%SiO_2+2}$
<ul style="list-style-type: none"> ▪ Cristobalite: Use ½ the value calculated from the count or mass formulae for quartz. ▪ Tridymite: Use ½ the value calculated from the formulae for quartz. 		
Amorphous, including natural diatomaceous earth	20	$\frac{80 \text{ mg/m}^3}{\%SiO_2}$
Silicates (less than 1% crystalline silica):		
Mica	20	
Soapstone	20	
Talc (not containing asbestos)	20 ^c	
Talc (containing asbestos) Use asbestos limit		
Tremolite, asbestiform (see 29 CFR 1910.1001)		
Portland cement	50	
Graphite (Natural)	15	
Coal Dust:		
Respirable fraction less than 5% SiO ₂ . . . . .	.....	2.4 mg/m ³ ^e
Respirable fraction greater than 5% SiO ₂ . . . . .	.....	$\frac{10 \text{ mg/m}^3 \text{ }^e}{\%SiO_2+2}$
Inert or Nuisance Dust: ^d		
Respirable fraction	15	5 mg/m ³
Total dust	50	15 mg/m ³

Note -- Conversion factors - mppcf X 35.3 = million particles per cubic meter = particles per c.c.

^a Millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques.

^b The percentage of crystalline silica in the formula is the amount determined from airborne samples, except in those instances in which other methods have been shown to be applicable.

^c Containing less than 1% quartz; if 1% quartz or more, use quartz limit.

CHEMICAL HYGIENE PLAN

^d All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by this limit, which is the same as the Particulates Not Otherwise Regulated (PNOR) limit in Table Z-1.

^e Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

Aerodynamic diameter (unit density sphere)	Percent passing selector
2	90
2.5	75
3.5	50
5.0	25
10	0

The measurements under this note refer to the use of an AEC (now NRC) instrument. The respirable fraction of coal dust is determined with an MRE; the figure corresponding to that of 2.4 mg/m³ in the table for coal dust is 4.5 mg/m³.