Safety Manual - Chapter 7
Generic Departmental Laboratory and Studio Hygiene Plan

Updated November 2, 2007

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Chemical Hygiene Plan Introduction

The purpose of this Chemical Hygiene Plan is to define work practices and procedures to help ensure that laboratory workers at Eastern Illinois University are protected from health hazards associated with the hazardous chemicals with which they work. The Chemical Hygiene Plan is part of the University's compliance with the regulations promulgated on January 31, 1990 by the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) entitled "Occupational Exposures to Hazardous Chemicals in Laboratories" (Code of Federal Regulations, 29 CFR 1910.1450).

OSHA has defined a hazardous chemical as a "chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principals that acute or chronic health effects may occur in exposed employees". In addition, OSHA defines a laboratory as "a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis". Finally, laboratory workers are defined in the OSHA Lab Standard under the definition of "employee" as "an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments." An example of a laboratory worker would be a University teaching assistant or faculty member instructing an academic lab; the students in the academic laboratory would not be considered laboratory workers. If there is any confusion about whether a particular workplace is considered a laboratory which utilizes hazardous chemicals, or whether someone is considered a laboratory worker, the Department's Chemical Hygiene Officer will upon request make this determination.

This Chemical Hygiene Plan shall be perused by all laboratory workers prior to the commencement of lab duties at the _____. In addition to the Plan, the laboratory workers shall be cognizant of and adhere to the Eastern Illinois University Safety Manual, Chapter 7, Laboratory and Studio Safety and any other sections of the Safety Manual relevant to their research. In addition to the formal health and safety policies found in the Safety Manual, the Environmental Health and Safety Department has prepared guidelines which represent prudent health and safety practices in a number of areas.

A written record stating that each laboratory worker has reviewed the Chemical Hygiene Plan and related health and safety policies and guides shall be kept by the person in charge of the lab or Department Chemical Hygiene Officer.

This Chemical Hygiene Plan (referred to as the Plan throughout this document) will be reviewed annually by the Chemical Hygiene Officer and/or the Environmental Health & Safety Committee.

Responsibilities

The division of responsibilities regarding general health and safety is outlined in the Safety Manual. Chapters 1 - 3 of the (Safety Manual) discusses responsibilities of the Department's Chemical Hygiene, Deans, Directors, Vice President, and Heads of Academic and Administrative Units; Supervisors; and Employees. Appropriate sections shall be reviewed by laboratory workers and their supervisors.

Specific to this Department's Chemical Hygiene Plan responsibilities include the following:

- Appoint a Department's Chemical Hygiene Officer who will routinely review the Chemical Hygiene Plan and suggest modifications as needed;
- Provide technical assistance to laboratory supervisors and workers concerning appropriate storage, handling and disposal of hazardous chemicals;
- Provide general laboratory safety training upon request;
- Conduct exposure assessments and laboratory inspections upon request and on a routine basis;
- Assist Health Services in medical consultation as needed;
- Provide technical assistance concerning personal protective equipment and laboratory safety equipment;
- Maintain a library of manufacturer's Material Safety Data Sheets and other laboratory and chemical safety literature; and,
- Remain current on rules and regulations concerning chemicals used on campus.
- Maintain and report if required to Department of Homeland Security, Appendix A of the Chemical Facility Anti-Terrorism Standards (CFATS), a critical element of its chemical security efforts.

Deans, Directors, and Heads of Academic and Administrative Units have the primary responsibility for the health and safety of their staff and students. Specific responsibilities regarding the implementation of the Chemical Hygiene Plan include:

- Collaborate with faculty and staff to taylor the Model Chemical Hygiene Plan to include lab-specific guidelines and to develop strategies to implement the Plan; and,
- Make and/or support budget requests for health and safety improvements.

Faculty and staff in charge of supervising laboratories (referred to as laboratory supervisors throughout document) have the following responsibilities for implementing the Chemical Hygiene Plan:

- Inform and train employees concerning chemical safety as required by this Plan;
- Implement and enforce rules and standards concerning health and safety for laboratories under supervisor's jurisdiction;
- Ensure compliance of laboratory workers with this Plan;
- Ensure the availability and enforce the use of appropriate personal protective equipment;
- Remain cognizant of chemicals stored and used in labs and their associated hazards;
- Conduct internal inspections of labs for health and safety concerns;
- Request assistance from the Environmental Health and Safety Department as needed; and,
- Request allocation of funds from superiors for health and safety improvements as needed.

Employee responsibilities regarding implementation of the Chemical Hygiene Plan:

- Follow all health and safety standards and rules;
- Report all hazardous conditions to the supervisor;
- Wear or use prescribed protective equipment;
- Report any job-related injuries or illnesses to the supervisor and seek treatment immediately;
- Refrain from the operation of any equipment or instrumentation without proper instruction and authorization;

- Remain aware of the hazards of the chemicals in the lab and how to handle hazardous chemicals safely; and,
- Request information and training when unsure how to handle a hazardous chemical or procedure.

Standard Operation Procedure

"Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals." 29 CFR 1910.1450(e)(i)

The Plan represents a minimum set of guidelines for the handling of toxic chemicals on campus. Individual administrative units, laboratories or research groups are required to develop more detailed procedures as their situations warrant. Acceptable lab safety references such as those listed in Appendix 1 of this document may be adopted in whole or may be useful in developing additional procedures. In all situations, individual faculty or staff will be responsible for enforcing adequate safety and hygiene measures in laboratories they supervise. If necessary, additional assistance from the Environmental Health and Safety Department is available.

Some rules or standard operating procedures which apply to all labs on campus include the following:

General

Respect and understand the safety and health hazards associated with the chemicals and equipment in your laboratory, and practice the following general safety guidelines at ALL times:

- Unattended experiments. Leaving hazardous systems unattended is not good practice.
- Working alone. When working with hazardous materials, it is advisable to have a second person present, or at a minimum, maintain surveillance via telephone contact.
- Housekeeping. Exits, aisles and safety equipment must NOT be obstructed in any way with equipment, furniture, etc. Work areas and floors are not to be used for excessive storage. No authorized items shall be stored in the corridors.
- Food, drink, cosmetics. Eating, drinking, and the application of cosmetics is forbidden in areas where hazardous chemicals are used and shall be done only in well-defined designated non-chemical areas. Do not store food in the same refrigerator with chemicals, biohazards or radioactive materials.
- **Horseplay. Horseplay is forbidden.**
- Equipment. Use proper equipment that is in good condition. For example, never use chipped or cracked glassware. Shield pressurized or vacuum apparatus and safeguard against bumping or overheating.
- Disposal of chemicals. Disposal of all laboratory waste shall follow the procedures outlined in a guide entitled Waste Disposal at Eastern Illinois University.
- Chemical spills and accident response. Consult the waste disposal guide concerning chemical spills. For large spills/leaks, call the Campus Police at Ext. 3211 and evacuate the area.
- Mouth pipetting. Mouth pipetting is forbidden.
- Mercaptans. To avoid false reporting of natural gas leaks, the Charleston Fire Department should be contacted (345-xxxx) when mercaptans will be used in a laboratory in such a manner that persons outside of the laboratory could smell the mercaptan and suspect a natural gas leak in the building.
- Perchloric acid. If perchloric acid is heated above ambient temperature, it will give off vapors that can condense and form explosive perchlorates. Hence, when heating perchloric acid above ambient temperature, a perchloric acid fume hood with a wash down system or a local scrubbing or trapping system should be used.

Personal Protection/Hygiene

Personal protection and personal hygiene are two very basic aspects of laboratory safety. Wearing appropriate personal protection and practicing good personal hygiene as described below will minimize exposures to hazardous chemicals during routine use and in the event of an accident.

- Attire. Wear a lab coat or apron, cover feet (no sandals or open-toed shoes), confine loose clothing and long hair.

- Gloves. Gloves are essential when working with hazardous substances. The proper gloves will prevent skin absorption, infection or burns. All glove materials are not equally effective in protection from chemical hazards. Consult a chemical resistance chart such as the one found in Appendix 2 or contact the Campus Safety Officer for assistance i appropriate selection.
- Eye protection. It is state law and campus policy (Chapter 4, section 11.51 of the Safety Manual) that personnel including students, staff and visitors in laboratories wear safety glasses, goggles, or face shields at all times where eye hazards are a possibility. Goggles are recommended when chemical splashes are possible.

  The wearing of contact lenses in labs is a controversial issue. If contact lenses must be worn, it is necessary to wear goggles at all times when in the lab. Contact lenses are not eye protection.
- Face shields. Face shields which cover the neck and ear areas should be worn when conducting a procedure which may result in a violent reaction.
- Glass tubing. When inserting tubing into stoppers, lubricate tubing and protect hands from being cut in the event of the tubing slipping and breaking.
- Personal hygiene. Hands should be washed frequently throughout the day, before leaving the lab, after contact with any hazardous material, and before eating or smoking.

Hazardous Material Handling and Storage

Hazards associated with various chemicals and gases vary widely. Understanding the hazards associated with a compound and minimizing the quantity used and stored in the lab will decrease chance of injury.

- Chemical storage. Chemical ideally should be stored by compatibility, not by alphabetical arrangement. Oxidizers should be separated from organics, air/water reactives must be kept dry and cyanides should be stored away from acids.

  Volatile toxic substances shall be stored in volatile storage cabinets adequate to the purpose, or in hoods when storage cabinets are unavailable. If volatile substances are stored in a hood, other uses of the hood shall be restricted to activities compatible with the chemical and physical properties of the stored or used chemicals. When volatiles must be stored in a cooled atmosphere, explosion-proof refrigerators or cold rooms designed for this purpose must be used.
- Chemical handling. Use bottle carriers for transporting chemicals which are in glass containers. Close caps securely and avoid storing chemical containers in hard to reach areas. Pour chemicals carefully, and never add water to concentrated acid. Metal containers and nonconductive containers (e.g., glass or plastic) holding more than five gallons must be grounded when transferring flammable liquids.
- Cylinder storage. Cylinders must be stored in well ventilated areas with their protective caps screwed on and the cylinder secured (e.g., strapped or chained down) to reduce the chance or the cylinder being knocked over. Do not store cylinders near heat or highly trafficked areas. Do not store flammables and oxidizers together. Do not store empty and full cylinders together. Storage of large quantities of cylinders must be done in an approved gas cylinder storage area.
- Cylinder handling. Use appropriate hand carts to move cylinders. Cylinders must be secured to the cart during transport. Highly toxic gases should not be moved through the corridors, particularly during business hours. Always consider cylinders as full and handle them with corresponding care.
- Labels. Make sure all labels are legible. Label all secondary containers with the chemical name and appropriate hazards. Date all peroxidizable and other chemicals which may become unstable over time; test and/or dispose of them when appropriate.
- Containers. Check the integrity of containers. Observe compatibilities, for example hydrofluoric acid must not be stored in glass and some oxidizers should not be stored in plastic containers.

Controlling Chemical Exposures

"Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practice; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous." 29 CFR 1910.1450(e)(ii)

There are three major routes of entry for a chemical to enter the body: inhalation, skin and eye contact, and ingestion. Three types of controls for prevention of these various routes of entry include: engineering controls, personal protective equipment and administrative controls. Each route of entry a chemical can take to enter the body can be controlled by a number of varying controls, as explained below.

Inhalation hazards

Inhalation of chemicals is the most common route of entry a chemical can take to enter the body. To avoid significant inhalation exposures, engineering controls such as substituting a less volatile or a less toxic chemical or substituting a liquid or solid chemical for a gaseous one are the best means of control. If substitution is not practical, ventilation should be used to lessen the chance of overexposure. The use of well-functioning local exhaust and other local exhaust systems is often required to minimize exposure to hazardous chemicals. Dilution ventilation may be used to reduce exposure to nonhazardous nuisance odors. For extremely toxic chemicals such as those classified as poison gases by State or Federal Department of Transportation (e.g., arsine, phosgene) the use of closed systems, vented gas cabinets, failsafe scrubbing, detection or other stricter controls may be required.

If both substitution and engineering controls are unavailable, the use of personal protective equipment may be required to reduce inhalation exposures. Respiratory protection from dust masks to self-contained breathing apparatus may be utilized to this end. If respirators are worn by laboratory employees, requirements of the OSHA Respirator Standard (1910.134) must be met. This Standard requires training on the proper use of respirators, medical surveillance to ensure the user is capable of wearing a respirator, and fit testing to ensure that the respirator fits properly. A lab worker or his/her supervisor should contact the Campus Safety Officer in the event that respiratory protection is utilized to control exposures to hazardous chemicals.

Finally, administrative controls can be utilized to reduce the risk of overexposure to hazardous chemicals. Some examples of administrative controls include:

- minimization of exposure time for individual employees;
- restricted access to an area where a hazardous chemical is used;
- allowing a process that emanates nuisance odors to be done only after typical office hours, when most of the staff in the building have gone home; and,
- proper signage on lab doors to indicate special hazards within, a list of lab supervisor and occupants of the lab who should be contacted in the event of an emergency, and appropriate telephone numbers.

Skin/eye contact hazards

To reduce the risk of a chemical entering the body via skin and eye contact, engineering controls include substitution and appropriate ventilation as described above in Inhalation hazards. The more obvious means of preventing skin and eye contact is the wearing of personal protective equipment such as eye protection, face shields, gloves, appropriate shoes, lab aprons, lab coats, and other protective equipment as appropriate to the hazard. Since the chemical resistivity of the different types of protective equipment varies significantly, the lab supervisor should consult Appendix 2 or other references to ascertain that the protective equipment material is resistant to the chemical being protected against.

Administrative controls to reduce skin/eye contact include:

- enforcement of policies pertaining to skin and eye protection; and,
- discarding or repair of cracked or broken glassware.

Ingestion

Ingestion of chemicals is the least common route of entry into the body. However a laboratory worker can easily ingest chemicals into the body via contaminated hands if they are not washed prior to eating, smoking or sticking part of the hand or a writing tool that has been in contaminated hands into the mouth. Some controls for preventing this route of exposure include engineering controls, such as isolating the hazardous substance so minimal contact is required (e.g., use glove box), personal protective equipment such as the wearing of gloves, and administrative

controls such as restricting mouth pipetting, encouraging good personal hygiene and designating a well marked nonchemical area where eating, drinking and the application of cosmetics is permitted.

At the request of faculty, staff or students, exposure evaluations may be conducted by the Environmental Health and Safety Department for any suspected overexposure to substances regulated by OSHA and/or ACGIH TLV's. [Note: ACGIH TLV is "American Conference of Governmental Industrial Hygienists Threshold Limit Value".] Records of exposure evaluations will be kept at the Campus Safety Officer.

Fume Hoods and Other Engineering Controls

"A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment." 29CFR 1910.1450(e)(iii)

All fume hoods on the EIU campus should comply with Campus Safety Manual. Adequately functioning fume hoods should be marked to indicate proper sash position for optimum hood performance. (In general fume hoods should not be used with the sash fully open.) Fume hoods and other engineering controls such as vented gas cabinets should be surveyed annually by a qualified person (from the Campus EHS office, Physical Plant, outside contractor, etc.) with a written report of the results maintained by the unit in charge of the lab.

In most cases, academic units are financially responsible for the maintenance and functionality of the fume hoods. Because of this, routine maintenance of fume hoods in some laboratory buildings on campus is not conducted. Hence, the users of the fume hoods and other ventilation equipment need to be certain that the equipment is functioning. A simple visible test to ensure flow into fume hoods, etc. is to tape a Kim Wipe to the hood and note its movement when the exhaust fan is turned on.

Protective equipment other than fume hoods should be checked periodically by the laboratory supervisor to ensure that the equipment is functioning properly.

Any questions or requests for assistance in evaluation of fume hoods and other protective equipment may be directed to the Environmental Health and Safety Department or the Physical Plant.

Employee Information and Training

"Provisions for employee information and training as prescribed in paragraph (f) of this section." 29 CFR 1910.1450 (e)(iv)

All individuals who work in laboratories who may be exposed to hazardous chemicals must be apprised of the hazards of chemicals present in their work area. This information and training as outlined below must be provided before initial assignment and before new exposure situations. Equipment necessary for the safe handling of hazardous substances must also be provided. Upon request by Departments or other administrative units, Environmental Health and Safety personnel will, from time to time, give presentations concerning general labs safety practices. However, training specific for the particular lab where and employee is assigned is the responsibility of the employee's supervisor. The frequency of refresher information and training shall be determined by the supervisor.

Information

Laboratory workers shall be informed of the location and availability of the following:

- 29 CFR Part 1910.1450 "Occupational Exposures to Hazardous Chemicals in Laboratories" (the OSHA Lab Standard);
- This Chemical Hygiene Plan;
- Reference materials on chemical safety, including Material Safety Data Sheets (MSDSs);
- Permissible exposure limits (PELs) for OSHA regulated substances, or if there is no applicable OSHA standard, the recommended exposure limits or threshold limit value (TLVs) may be provided; and,
- Signs and symptoms associated with exposure to the hazardous chemicals found in the lab.

Training

Laboratory worker training shall include:

- Detection methods and observations that may be used to detect the presence or release of a hazardous chemical. Examples of detection methods include visual appearance, odor, and an understanding of chemical monitoring devices;
- Physical and health hazards of the chemicals; and,
- The work practices, personal protective equipment, and emergency procedures to be used to ensure that the employee may protect himself/herself from overexposure to hazardous chemicals.

The manufacturer's Material Safety Data Sheets will generally contain much of the above information needed to comply with the information and training requirements of the OSHA Lab Standard. Hence, employees should peruse and understand the relevant MSDSs and/or other comparable literature on the hazardous chemicals which are used or stored in their laboratory. Additional training for specific lab hazards must be provided by the employee's supervisor.

The OSHA Lab Standard, the EIU Chemical Hygiene Plan, a library of MSDSs and other health and safety references are maintained at the Environmental Health and Safety Department, Central Stores, and are available to students, faculty or staff upon request. A list of safety and industrial hygiene literature available from the Campus Safety Officer is found in Appendix 1 of this document.

Copies of MSDSs may be obtained from the chemical supplier or from the Division of Environmental Health and Safety. Though the Campus Safety Officer maintains a library of MSDSs, individual departments or laboratories are required to maintain their own files of Material Safety Data Sheets and other reference materials.

Prior Approval

"The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation." 29 CFR 1910.1450(e)(v)

The responsibility for approval of the acquisition and use of toxic chemical agents rests with the laboratory supervisor. Certain materials including radioactive materials, recombinant DNA and certain biohazards require prior internal approval at various levels. If there are questions concerning the need for approval, the Campus Safety Officer should be consulted.

Medical Consultation

"Provisions for medical consultation and medical examination in accordance with paragraph (g) of this section." 29 CFR 1910.1450(e)(3)(vi)

An opportunity to receive medical consultation shall be provided under the following circumstances: if an employee develops any symptoms thought to arise from chemical overexposure; after an event such as a major spill, leak or explosion which may have resulted in an overexposure; or, an overexposure is identified as the result of an evaluation by the Chemical Hygiene Officer. Health Service will designate one or more physicians at any given time to be consulting physicians. Following notification of overexposure, arrangements for an appropriate medical examination must be completed before the exposed individual may return to work. Any medical examination required by this Plan shall be provided without cost to the employee, without loss of pay and at a reasonable time and place. Records of any medical examination will be maintained at Health Service.

Chemical Hygiene Officer

"Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee." 29 CFR 1910.1450(e)(3)(vii)

The Departmental Chemical Hygiene Officer or Division staff person designated by the Dean will be designated as the Chemical Hygiene Officer for College. The Eastern Illinois University Environmental Health and Safety Committee will serve at the Eastern Illinois University Chemical Hygiene Committee.

Special Provisions for Select Carcinogens, Reproductive Toxins and Acutely Toxic Chemicals

"Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate: (A) Establishment of a designated area (B) Use of containment devices such as fume hoods or glove boxes; (C) Procedures for safe removal of contaminated waste; and (D) Decontamination procedures." 29 CFR 1910.1450(e)(e)(viii)

In addition to the general safety guidelines mentioned in the first section and throughout the Plan, special precautions are needed when handling genotoxins, reproductive toxins and chemicals with a high degree of acute toxicity. A minimum set of guidelines that should be followed are listed below. The lab supervisor should ensure that these and other precautions designed to minimize risk of exposure to these substances are taken.

- Quantities of these chemicals used and stored in the laboratory should be minimized, as should their concentrations in solution or mixtures.
- * Work with genotoxins, reproductive toxins and acutely toxic chemicals should be performed within a functioning fume hood, biological safety cabinet, ventilated glove box, sealed system, or other system designed to minimize exposure to these substances. (The exhaust air from the ventilation systems may require scrubbing before being released into the atmosphere.) In all cases, work with these types of chemicals shall be done in such a manner that the OSHA permissible exposure limits or similar standards are not exceeded.
- Compressed gas cylinders which contain acutely toxic chemicals such as arsine and nitrogen dioxide should (and may be required to) be kept in ventilated gas cabinets.
- The ventilation efficiency of the designated fume hood, glove box or gas cabinet, and the operational effectiveness of mechanical and electrical equipment used to contain or manipulate these special substances should be evaluated periodically by the laboratory personnel at intervals determined by the laboratory supervisor. The interval of evaluating systems may vary from weekly to biannually depending upon the frequency of usage, quantities employed and level of hazard.
- Each laboratory utilizing these substances must designate an area for this purpose and must sign or mark this area with an appropriate hazard warning. The designated area may be an entire laboratory, an area of the laboratory or a device such as a fume hood or glove box. the designated area should be marked with a DANGER, specific agent, AUTHORIZED PERSONNEL ONLY or comparable warning sign.
- All laboratory workers who work in a laboratory which has an area designed for use with genotoxins, reproductive toxins and acutely toxic chemicals must be trained about the deleterious effects of these substances as well as signs and symptoms regarding exposure to these substances, whether or not they actually work with the substance themselves. Training to ensure the safe handling and storage of these substances is required for those who use these materials. This training is the responsibility of the laboratory supervisor and must be done prior to the use of any of these materials.
- Laboratory workers working with these chemicals must have access to appropriate protective equipment and clothing (available at no expense to the workers) and must be trained on how to properly utilize the safety equipment. For example, when working with highly toxic gases, it is often recommended that the workers have available and be trained to use self-contained breathing apparatus.
- Detection equipment may be required in laboratories where chemicals (especially poisonous gases) with a high degree of acute toxicity are utilized.
- All wastes contaminated with these substances should be collected and disposed of in a timely manner and appropriately as outlined in the the Campus Safety Officer waste disposal guide mentioned previously. For special disposal information, call the Campus Safety Officer (Ext. 3727). If possible and as soon as practical, waste products shall be destroyed by a suitable, generally acceptable chemical procedure to lessen or eliminate their toxicity.
- The designated working area shall be thoroughly and appropriately decontaminated and cleaned at regular intervals determined by the laboratory supervisor. The interval may be as short as one day or as long as six months depending upon the frequency of usage and level of hazard. * Special precautions to avoid release and exposure to highly toxic chemicals, genotoxins and reproductive toxins must be utilized. For instance, volatile substances should be kept cool and contained; gases should have properly functioning valves, check valves, regulators, containment which can withstand pressure buildup, and appropriate piping; and

dispersive solids should be kept in closed containers, used in places with minimum air currents, and appropriate contact materials should be used to avoid static charging.

- Emergency response planning for releases or spills shall be prepared by the lab supervisor and included in the training of the laboratory workers and others who may be affected in the building. The Campus Safety Officer and the Charleston Fire Department should be involved in this planning.

Appendix 1

References available at the Environmental Health and Safety Department as of May 1, 1992:

- Safety Manual, Chapter 7, Laboratory and Studio Safety, Eastern Illinois University, Charleston, Illinois.
- Handbook of Compressed Gases, 3rd ed., Compressed Gas Association, Arlington, Virginia, 1990.
- Handbook of Laboratory Safety, 3rd ed., edited by A. Keith Furr, CRC Press, 1990.
- Hawley's Condensed Chemical Dictionary, 11th ed., Irving Sax and Richard J. Lewis, Sr., Van Nostrand Reinhold Company, 1978.
- Industrial Ventilation, 20th ed., American Conference of Governmental Industrial Hygienists, 1988.
- Laboratory Safety Manual, Indiana University Department of Chemistry, Bloomington, Indiana, 1989.
- Laboratory Safety: Practices for Progress, University of Michigan Department of Occupational Safety and Environmental Health, 1990.
- NIOSH Pocket Guide to Chemical Hazards, DHHS (NIOSH), June 1990, DHHS (NIOSH) Publication No. 90-117.
- OSHA Safety and Health Standards, (29 CFR 1910), United States Department of Labor, U.S. Government Printing Office, 1988.
- Patty's Industrial Hygiene and Toxicology, 3rd ed., Patty, F.A., Volumes 1.2(A,B,C), and 3(A,B), Wiley-Interscience, 1978.
- Prudent Practices for Disposal of Chemicals from Laboratories, National Research Council, National Academy Press, 1983.
- Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Research Council, National Academy Press, 1981.
- Purdue Right-to-Know and Hazardous Materials Safety Manual, Purdue University RAdiological and Environmental Management, West Lafayette, Indiana. Appendix 1, Cont.
- Safety in Academic Chemistry Laboratories, 5th ed., Committee on Chemical Safety, American Chemical Society: Washington, D.C., 1990.
- TLVs: Threshold Limit Values and Biological Exposures Indices for 1988-1989, American Conference of Governmental Industrial Hygienists, 1988.

Appendix 2

Resistance to Chemicals of Common Glove Materials (E=Excellent; G=Good; F=Fair; P=Poor)

Chemical	Natural Rubber	Neoprene	Nitrile	Vinyl
Acetaldehyde	G	G	E	G
Acetic acid	E	E	E	E
Acetone	G	G	G	F
Acrylonitrile	P	G	----	F
Ammonium hydroxide (sat)	G	E	E	E

Aniline	F	G	E	G
Benzaldehyde	F	F	E	G
Benzenea	P	F	G	P
Benzyl chloridea	F	P	G	P
Bromine	G	G	----	G
Butane	P	E	----	P
Butyraldehyde	P	G	----	G
Calcium hypochlorite	P	G	G	G
Carbon disulfide	P	P	G	F
Carbon tetrachloridea	P	F	G	F
Chlorine	G	G	----	G
Chloroacetone	F	E	----	P
Chloroforma	P	F	G	P
Chromic acid	P	F	F	E
Cyclohexane	F	E	----	P
Dibenzyl ether	F	G	----	P
Dibutyl phthalate	F	G	----	P
Diethanolamine	F	E	----	E
Diethyl ether	F	G	E	P
Dimethyl sulfoxideb	----	----	----	----
Ethyl acetate	F	G	G	F
Ethylene dichloridea	P	F	G	P
Ethylene glycol	G	G	E	E
Ethylene trichloridea	P	P	----	P
Fluorine	G	G	----	G
Formaldehyde	G	E	E	E
Formic acid	G	E	E	E
Glycerol	G	G	E	E
Hexane	P	E	----	P
Hydrobromic acid (40%)	G	E	----	E
Hydrochloric acid (conc)	G	G	G	E
Hydrofluoric acid (30%)	G	G	G	E
Hydrogen peroxide	G	G	G	E

Iodine	G	G	----	G
Methylamine	G	G	E	E
Methyl cellosolve	F	E	----	P
Methyl chloridea	P	E	----	P
Methyl ethyl ketone	F	G	G	P
Methylene chloridea	F	F	G	F
Monoethanolamine	F	E	----	E
Morpholine	F	E	----	E
Naphthalenea	G	G	E	G
Nitric acid (conc)	P	P	P	G
Perchloric acid	F	G	F	E
Phenol	G	E	----	E
Phosphoric acid	G	E	----	E
Potassium hydroxide (sat)	G	G	G	E
Propylene dichloridea	P	F	----	P
Sodium hydroxide	G	G	G	E
Sodium hypochlorite	G	P	F	G
Sulfuric acid (cone)	G	G	F	G
Toluenea	P	F	G	F
Trichloroethylenea	P	F	G	G
Tricresyl phosphate	P	F	----	F
Triethanolamine	F	E	E	E
Trinitrotuluene	P	E	----	P

Aromatic and halogenated hydrocarbons will attack all types of natural and synthetic glove materials. Should swelling occur, the user should change to fresh gloves and allow the swollen gloves to dry and return to normal. bNo data on the resistance to dimethyl sulfoxide of natural rubber, neoprene, nitrile rubber, or vinyl materials are available; the manufacturer of the substance recommends the use of butyl rubber gloves.

Taken from Prudent Practices for Handling Hazardous Chemicals in Laboratories, 1981

Resistant Properties of Selected Materials by Chemical Class

Chemical	Butyl	Viton/CPE	Natural Neoprene	Rubber	Neoprene
Acids, carboxylic & aliphatic					
Unsubstituted	R	r	r	**	rr

Polybasic					rr
Aldehydes					
Aliphatic and alicyclic	RR	NN	r	**	NN
Aromatic & heterocyclic	rr		n	nn	nn
Amides	rr		**	nn	
Amines, aliphatic & alicyclic					
Primary	**	**	n	NN	**
Secondary	**		n	NN	nn
Tertiary	**	**		**	**
Polyamine	**			NN	**
Cyanides				r	
Esters, carboxylic					
Formate			n		
Acetates	**	**	n	NN	nn
Higher monobasic	nn	nn	**	NN	nn
Polybasic		r	r	r	
Aromatic phthalate	rr		r	**	**
Ethers					
Aliphatic	**	rr	**	NN	**
Halogen compounds					
Aliphatic, unsubstitued	nn	nn	r	NN	NN
Aliphatic, substituted	**			NN	rr
Aromatic, unsubstituted	nn	nn	r	N	
Polynuclear				NN	nn
Vinyl halides					
Heterocyclic compounds					
Epoxy compounds	**			**	nn
Furan derivatives	nn		nn		
Hydrazines	**	nn	n	**	**
Hydrocarbons					
Aliphatic & alicyclic	N	r	r	NN	**
Aromatic	**	rr	r	NN	NN
Hydroxyl compnounds					
Aliphatic & alicyclic					
Primary	RR	rr	rr	nn	**
Secondary	rr	rr	r	**	**

Tertiary	r			**	rr
Polyois	r		**	rr	rr
Aromatic	**		r	**	**
Inorganic acids	**	**	rr	**	**
Inorganic bases	r	r		RR	RR
Inorganic gases	**	r	n	n	r
Inorganic salts	r		n	**	r
Isocyanates				NN	n
Ketones, aliphatic	**	NN	n	NN	NN
Nitriles, aliphatic	rr			NN	**
Nitro compounds					
Unsubstituted	rr	r		NN	**
Organo-phosphorous compounds			r		
Peroxides				r	
Sulfur compounds					
Thiois		**			

Resistant Properties of Selected Materials by Chemical Class

Chemical	Nitrile + PVC	Nitrile	PE	PVA	PVC	Viton	Butyl/Neoprene
Acids, carboxylic & aliphatic							
Unsubstituted	**	rr	NN	**	**	**	r
Polybasic	rr	rr	n		rr		
Aldehydes							
Aliphatic & alicyclic	nn	NN	**	NN	NN	**	r
Aromatic & heterocyclic	n	nn	NN	rr	N	r	
Amides							
Amines, aliphatic & alicyclic							
Primary		rr		nn	**	**	
Secondary		**		**	NN	nn	n
Tertiary	**	**		**	**	rr	
Polyamine	nn				NN	rr	
Cyanides							
Esters, carboxylic							
Formate					n		n
Acetates	nn	NN	NN	**	NN	n	**

Higher monobasic		nn	NN	rr	NN		**
Polybasic		**			rr		r
Aromatic phthalate					nn	rr	r
Ethers							
Aliphatic	**	**		**	**		**
Halogen compounds							
Aliphatic unsubstituted	NN	NN	NN	**	NN	**	n
Aliphatic substituted		nn		**	NN	rr	
Aromatic unsubstituted	n	nn	NN		N	rr	n
Polynuclear					n	rr	
Vinyl halides					n	rr	
Heterocyclic compounds							
Epoxy compounds		nn	NN	**	nn	NN	
Furan derivatives					NN	nn	n
Hydrazines	**	nn	**	**	n		
Hydrocarbons							
Aliphatic & alicyclic	**	**	**	**	NN	RR	n
Aromatic	NN	**	NN	**	NN	RR	r
Hydroxyl compounds, aliphatic & alicyclic							
Primary	nn	**	**	**	**	rr	**
Secondary	**	rr		rr	**	rr	r
Tertiary	rr	rr			**		
Polyois	rr	rr			**		**
Aromatic	**	**	**	nn	**	rr	r
Inorganic acids	**	**	**	n	**	rr	**
Inorganic bases	**	RR	**	n	**	rr	r
Inorganic gases			**	n	**	**	**
Inorganic salts	r	r			R		
Isocyanates							
Ketones, aliphatic	N	**	NN	**	NN	NN	**
Nitriles, aliphatic			NN	rr	NN	rr	
Nitro compounds, unsubstituted		nn		**	**	**	
Organo-phosphorous compounds							
Peroxides							
Sulfur compounds							

Thiois							n

Legend:

- **RR, R, rr and r** represent positive degrees of resistance.
- **NN, N, nn and n** represent degrees of poor resistance.
- **Double characters** indicate that the rating is based on test data.
- **Single characters** indicate that the rating is based on qualitative data.
- **Upper-case letters** indicate a large body of consistent data.
- **Lower-case letters** indicate either a small quantity of data or inconsistent information.
- **Asterisks (**)** mean that the material varied considerably in its resistance to chemicals within a given class and data for specific chemicals should be used it available.
- Butyl - Butyl rubber
- CPE - Chlorinated polyethylene
- Viton/Neoprene - layered material, 1st mat. on surface
- Natural rubber - same
- Neoprene - same
- Nitrile + PVC - Nitrile rubber + polyvinyl chloride
- Nitrile - Nitrile rubber PE - Polyethylene
- PVA - Polyvinyl alcohol
- PVC - Polyvinyl chloride
- Viton - same
- Butyl/Neoprene - layered material - first material on surface

Taken from CRC Handbook of Laboratory Safety, 3rd ed.