Chemical Hygiene Plan
&
Laboratory Safety Manual

https://wp.stolaf.edu/chemical-hygiene/

All laboratory workers must read and understand this Manual*
before
working with or near chemicals on campus.

"Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

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

(ii) Capable of keeping exposures below the limits specified [in 29 CFR part 1910, subpart Z]."

29 CFR 1910.1450(e)(1)

"The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the [OSHA] Assistant Secretary."

29 CFR 1910.1450(e)(2)

* *This manual is intended for use by FNSM employees who work in Regents Hall of Natural Sciences. Academic-related employees who work in the Dittmann Center or Speech Theater follow the "Art Safety Manual." Facilities personnel follow the policies and guidelines outlined in the "Employee Right-To-Know Written Program."*

Implemented: January 1991
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Updated by:

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Dr. Patrick A. Ceas
Chemical Hygiene Officer
St. Olaf College
(signee for the St. Olaf College)

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CHAPTER 1

"Introduction: Why Must I Read, Understand, and Follow this Safety Manual?"

1.1 WHY DO WE HAVE THIS MANUAL?

(adapted and modified from the Univ. Minnesota "Laboratory Safety Plan" http://www.dehs.umn.edu/safety/lsp/intro.html)

1.1.a To Provide Safety Guidelines & Policies. The St. Olaf College Chemical Hygiene & Safety Manual is intended to provide guidelines and policies that, when properly followed, are capable of protecting employees, students, visitors, and the surrounding community from harmful exposure to, and health hazards associated with, hazardous chemicals.

1.1.b To Comply with and Meet Regulatory Requirements. This Manual is intended to meet the requirements of:

(1) the Occupational Health and Safety Administration (OSHA) "Laboratory Standard" (29 CFR 1910.1450), formally known as "Occupational Exposure to Hazardous Chemicals in Laboratories; Final Rule" (reproduced in Appendix B),
(2) the Minnesota Employee Right To Know Act (MERTKA), and
(3) other relevant standards summarized in Section 1.5.

1.1.c To Evaluate the Workplaces for Hazards.

MERTKA requires employers to evaluate their workplaces for the presence of hazardous substances, harmful physical agents, and infectious agents and to provide training to employees concerning those substances or agents to which employees may be exposed. Written information on agents must be readily accessible to employees or their representatives. Employees have a conditional right to refuse to work if assigned to work in an unsafe or unhealthful manner with a hazardous substance, harmful physical agent or infectious agent. Labeling requirements for containers of hazardous substances and equipment or work areas that generate harmful physical agents are also included in MERTKA.

1.1.d To Eliminate Hazards or Reduce Risks. The guidelines and policies found in this Manual are designed to eliminate hazards or at least (if followed properly) reduce risks to ensure a safe and healthy work environment for all laboratory workers, students, visitors, and the surrounding community:

(1) Administrative Controls.
(2) Engineering Controls.
(3) Personal Protective Equipment.
(4) Standard Operating Procedures.

1.1.e To Avoid Exposure Limits or Action Levels. This Manual is intended to provide policies and procedures that, when followed properly, will safely limit laboratory workers' exposure to OSHA-regulated substances.

(1) Laboratory workers must not be exposed to substances in excess of the Permissible Exposure Limits (PELs) specified in OSHA Rule 29 CFR 1910, Subpart Z, Toxic and Hazardous Substances.
(2) Certain substances have "Action Levels" - air concentrations below the PEL - that nevertheless require that certain actions such as medical surveillance and workplace monitoring take place.

1.1.f To Ensure the Medical Surveillance of Employees.

An employee's workplace exposure to any regulated substance must be monitored if there is reason to believe that the exposure will exceed an Action Level or a PEL. If exposures to any regulated substance routinely exceed an action level or permissible exposure level there must also be employee medical exposure surveillance.

1.2 THE OSHA "LABORATORY STANDARD" – WHY WAS IT WRITTEN?

Numerous regulations affect laboratory employees who work with or may be exposed to hazardous chemicals. The Occupational Safety and Health Administration (OSHA) administers a variety of federal regulations related to occupational safety and health issues. These regulations, found in Part 1910 of Title 29 of the Code of Federal Regulations (cited as "29 CFR 1910"), are divided into Subparts A through Z. Subpart Z addresses specifically the use of toxic and hazardous substances, and includes regulations designed to protect all employees from harmful exposure to, and associated health hazards associated with, hazardous chemicals.

On November 25, 1983, OSHA published the Hazard Communication Standard (cited as "29 CFR 1910.1200"), which applied to certain manufacturers and in part to certain laboratories. This Standard requires that employers develop, implement, and maintain a written Hazard Communication Program that provides information to their employees about the hazardous chemicals to which they are exposed, and is designed to ensure the safety of employees from exposure to hazardous chemicals by including information on:

- labels and other forms of warning,
- material safety data sheets,
- information and training,
- how the employer will implement the Program,
- a list of the hazardous chemicals known to be present,
- the methods the employer will use to inform employees of the hazards of non-routine tasks, and
- the methods the employer will use to inform employees of chemicals contained in unlabeled pipes in their workstation.

OSHA received many comments regarding whether the procedures of the Hazard Communication Standard should apply to laboratories where the staff is usually "highly educated." OSHA decided although "*31.9% of all laboratory workers have bachelors degrees, 20.6% have masters degrees, and 20.9% have doctorates, … there is some question as to whether laboratory workers actually make themselves as knowledgeable as they should be and some laboratory employees are not professionally trained.*" Other unique differences for laboratories were noted, including: the small amounts of chemicals used; the vast numbers of different chemicals involved; and that nearly half of the laboratories in one survey could not accurately predict their chemical needs even one month in advance.

OSHA decided that "*Despite the existence of the unique characteristics of laboratory work places, in actual practice incidents of acute adverse health effects resulting from exposures to toxic substances in laboratories do occur. Furthermore, some studies … have shown increased risks of certain types of diseases for laboratory workers. In addition, although laboratory workers are, in general, a well educated work force, there is evidence that many laboratories do not have health and safety programs…* ". Therefore, on January 31, 1990, OSHA published in the Federal Register an amendment to 29 CFR 1910, Subpart Z, identified as Section 1910.1450. The title of this amendment is "Occupational Exposures to Hazardous Chemicals in Laboratories; Final Rule" but it is better known as the "Laboratory Standard."

1.3 THE LABORATORY STANDARD – A BRIEF OVERVIEW

(The entire document is reproduced in Appendix B, and can be viewed online at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10106&p_table=STANDARDS)

1.3.a Effective Dates. The effective date of the Laboratory Standard was May 1, 1990. A primary requirement of the standard is a written Chemical Hygiene Plan, to be developed and implemented by January 31, 1991. St. Olaf College met this deadline.

1.3.b Scope and Application. The Laboratory Standard applies to employers and employees who are involved with the laboratory use of hazardous chemicals (as explained in Sections 1.3.c-1.3.g below). It supersedes the requirements of all other OSHA health standards in 29 CFR 1910 subpart Z except for the following:

(1) If the Action Level (or in the absence of an Action Level, the Permissible Exposure Limit) is routinely exceeded for an OSHA regulated substance, then exposure monitoring and medical surveillance must take place.

(2) The prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

1.3.c What is a "Hazardous Chemical?" See Chapter 5 for examples. As defined in the OSHA Laboratory Standard, a hazardous chemical is a chemical:

> "for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees" (29 CFR 1910.1450(b))

1.3.d What is a "Laboratory?" As defined in the OSHA Laboratory Standard, a laboratory is a facility where:

(1) The "laboratory use of hazardous chemicals" occurs, and

(2) Relatively small quantities of hazardous chemicals are used on a non-production basis.

1.3.e What is Meant by the "Laboratory Use of Hazardous Chemicals?" "Laboratory use of hazardous chemicals" means the handling or use of such chemicals in which all of the following conditions are met:

(1) The handling or use of chemicals occurs on a 'laboratory scale', that is, the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.

(2) Multiple chemical procedures or chemical substances are used.

(3) The procedures involved are not part of a production process, nor in any way simulate a production process.

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

1.3.f Who is Covered/Affected by the Laboratory Standard?

(1) At a minimum, these regulations apply to employees (including faculty, staff, student-employees, visiting researchers, and supervisors) who use chemicals in teaching/research/clinical laboratories or stockrooms at St. Olaf College. These persons are required to follow all relevant policies, procedures, and guidelines presented in this manual, and St. Olaf College is required to ensure that the employees follow all policies.

(2) Certain non-traditional settings where laboratory-like activities may occur may be included under this standard at the option of St. Olaf College CHO in consultation with individuals and affected academic departments.

(3) It is the policy of the College that laboratory students, while not legally covered under this standard, will be given training commensurate with the level of hazard associated with their laboratory work.

1.3.g Who/What is Not Covered by the Laboratory Standard? This Standard does not apply to:

(1) Laboratories whose function is to produce commercial quantities of material (St. Olaf has no such laboratories).

(2) Laboratory use of chemicals that provide no potential for employee exposure. Examples of such conditions might include:

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

(3) Facilities staff are covered by (and must follow) the St. Olaf Hazard Communication Program.
(4) Fine Arts faculty/staff are covered by (and must follow) the St. Olaf Arts Safety Manual.

1.3.h Chemical Hygiene Plan. As required in the Laboratory Standard (29 CFR 1910.1450(e)(1)), "Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan."

(1) **Main Goals.** The Chemical Hygiene Plan (CHP), developed and implemented by the employer, sets forth procedures, equipment, personal protective equipment and work practices that are capable of:
(a) Protecting employees from the health hazards associated with hazardous chemicals used in that particular workplace.
(b) Keeping exposures below the Permissible Exposure Limits specified in 29 CFR 1910, subpart Z.

(2) **Readily Available.** The CHP must be readily available to employees, employee representatives, and the OSHA Assistant Secretary of Labor.
(a) The St. Olaf College Chemical Hygiene Plan can be found online at http://www.stolaf.edu/services/chemical-hygiene/.
(b) A **hardcopy** of the CHP is located in every Regents Hall stockroom, teaching/research laboratory, and the departmental offices.

1.4 THE CHEMICAL HYGIENE PLAN – WHAT IS REQUIRED?

1.4.a Required Elements. The following elements, taken from the Laboratory Standard, are required to be included in an institution's CHP, and the CHP must include specific measures that the employer will take to ensure that these elements are followed.

(1) **Standard Operating Procedures** relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals.
(2) **Criteria** the employer will use **to implement control measures** to reduce employee exposure to hazardous chemicals, including:
(a) Engineering controls,
(b) The use of personal protective equipment,
(c) Personal hygiene practices.
(3) **Fume Hoods.** The CHP must include **a requirement** that **fume hoods and other protective equipment** are **functioning properly**, and that specific measures are taken to ensure proper and adequate performance of such equipment.
(4) **Employee Information and Training.**
(a) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.
(b) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations.
(c) The frequency of refresher information and training shall be determined by the employer.
(5) **Prior Approval.** The CHP must include circumstances under which a particular laboratory operation, procedure, or activity shall require prior approval from the employer or the employer's designee before implementation.
(6) **Medical Consultation and Examination.** The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following conditions:
(a) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.

(b) Where exposure monitoring reveals an exposure level routinely above the Action Level (or, in the absence of an Action Level, the PEL) for an OSHA regulated substance, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

(c) Whenever an event takes place in the work area such as a spill or leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure.

(7) **Responsibilities.** The CHP must include designations 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.

(8) **Particularly Hazardous Substances.** The CHP must include provisions for additional protection for employees working with particularly hazardous substances including:

(a) Select Carcinogens,

(b) Reproductive Toxins, and

(c) Substances with High Degree of Acute Toxicity.

(d) Specific consideration shall be given to the following provisions, which shall be included where appropriate:

(i) Establishment of a Designated Area.

(ii) Use of containment devices such as fume hoods or glove boxes.

(iii) Procedures for safe removal of contaminated wastes.

(iv) Decontamination procedures.

(9) **Hazard Identification.**

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

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

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

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

(i) If the composition of the chemical substance is known, the employer shall determine if it is a hazardous chemical. If the chemical is determined to be hazardous, the employer shall provide appropriate training.

(ii) If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall follow all appropriate safety & standard operating procedures.

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

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

(11) **Recordkeeping.** The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard. The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.1020.

(12) **Review & Update of CHP.** The employer shall review and evaluate the effectiveness of the CHP at least annually, and update it as necessary.

1.4.b Recommended Elements. In addition to the required elements, Appendix A of the Laboratory Standard provides a series of "Recommendations Concerning Chemical Hygiene in Laboratories." These recommendations are followed by St. Olaf College and can be found in the appropriate sections of the St. Olaf College Chemical Hygiene Plan & Laboratory Safety Manual.

1.5 OVERVIEW OF ADDITIONAL REGULATORY INFORMATION

As stated in sections 1.2 and 1.3, the Laboratory Standard is the primary OSHA regulation concerning work with chemicals in academic laboratories, and supercedes the requirements of all other health standards in 29 CFR 1910 Subpart Z except for the requirement of limiting exposure levels to below the PELs (29 CFR 1910.1000-1910.1052). While the Laboratory Standard supersedes the remaining sections of Subpart Z, other standards not specifically addressed remain applicable. For example, Subpart H of 29 CFR 1910 addresses physical hazards such as compressed gases, flammable liquids, and combustible liquids, Subpart I of 29 CFR 1910 addresses personal protective equipment, and Subpart G addresses ionizing and non-ionizing radiation.

Besides OSHA standards, the Minnesota Pollution Control Agency governs the management of hazardous wastes, and protection from radiation hazards is regulated by both OSHA and the Nuclear Regulatory Commission. In addition, components of the Toxic Substances Control Act apply to academic laboratories. Also applicable is the General Duty Clause, which is explained below.

1.5.a General Duty Clause (29 USC 654 5(a) & (b) and Minnesota Statute 182.653, Subdiv.2)

(1) The purpose of the General Duty Clause is to assure that the workplace is free from recognized hazards that are causing or likely to cause serious physical harm to employees.
(2) The General Duty Clause must not be used in cases where a specific standard exists and may not be used to set a higher level of protection then is provided for in a standard.
(3) Any serious hazard not covered by a specific provision of OSHA may be subject to a citation under the General Duty Clause.
(4) The General Duty Clause can be cited when:
    (a) Employees were exposed to a hazard.
    (b) The employer failed to keep the workplace free of the hazard or should have recognized the hazard based on industry standards or national consensus standards.
    (c) The hazard is likely to cause death or serious physical harm.
    (d) A feasible method is available to correct the hazard.

1.5.b Minnesota Employee Right-To-Know Act, MR 5206 (http://www.revisor.leg.state.mn.us/arule/5206/)

OSHA has allowed individual states to develop their own set of safety standards, provided that the standards are at least as encompassing as 29 CFR 1910. Minnesota has opted to become one of these "state plan states" and has issued its own Minnesota Employee Right-To-Know Act (MERTKA). This rule is enforced by the Minnesota OSHA, and supersedes the federal OSHA Hazard Communication Standard. It covers (in addition to hazardous substances) harmful physical agents, infectious agents, and non-ionizing radiation. Furthermore, **MERTKA requires employee annual refresher training in addition to initial time-of-hire training.**

1.5.c Hazardous Materials, 29 CFR 1910 Subpart H (1910.101-126)

While the Laboratory Standard exempts laboratories from most provisions of 29 CFR 1910 subpart Z, other subparts including Subpart H, Hazardous Materials, apply. Subpart H provides protection against the hazards of numerous substances including compressed gases, flammable and combustible liquids, explosives and anhydrous ammonia.

1.5.d Personal Protective Equipment, 29 CFR 1910 Subpart I (1910.132-138)

Subpart I of 29 CFR 1910 ensures that employees are provided with and have appropriate training in the use of personal protective equipment including eye protection, face protection and respiratory tract protection. Also applicable are associated **American National Standard Institute** (**ANSI**) Standards.

1.5.e Radiation Hazards

Protection from the hazards associated with radiation including ionizing radiation, non-ionizing radiation and radioactive materials is required by several regulations. OSHA 29 CFR 1910.97 along with the Atomic Energy Act, the Energy Reorganization Act, and the Nuclear Regulatory Commission all establish standards of protection, exposure limits, and licensing requirements. All work with radioactive materials and equipment that produce radiation (shorter than UV wavelength) at St. Olaf College is regulated by the "Procedures for the Use of Radioisotopes at St. Olaf College."

1.5.f Hazardous Waste Management

The EPA Resource Conservation and Recovery Act (RCRA) is the primary set of regulations for the proper handling and disposal of hazardous waste (http://www.epa.gov/rcraonline/). Minnesota, like many other states, has adopted and expanded upon these regulations. The Minnesota Pollution Control Agency oversees the proper management of hazardous waste and has a series of regulations (http://www.pca.state.mn.us/waste/hw_mnrules.html). Included are manifesting rules, storage rules, record-keeping requirements, training requirements and emergency response requirements. Also applicable are 49 CFR 100 to 199 (Department of Transportation Rules). **Read and follow the provisions of Chapter 10 of the Manual (Waste Disposal Program) to ensure compliance with these rules and requirements.**

1.5.g Toxic Substances

The purpose of the Toxic Substances Control Act (http://www.epa.gov/Region5/defs/html/tsca.html) is to control new or existing chemicals that may present unreasonable health risks. The part of TSCA that directly affects research laboratories is Part 8c, which includes record keeping requirements for significant adverse reaction allegations.

1.5.h Controlled Substances

The purchase, use, storage, and disposal of controlled substances is regulated by the U.S. Drug Enforcement Agency (21 CFR, Part 1300 to end), Minnesota Statutes Chapter 152, and the Minnesota Board of Pharmacy, Chapter 6800.4210-4250. Refer to the college's Controlled Substances Policy for additional information.

1.5.i Fire Protection and Safety

Fire protection and fire safety are addressed in the OSHA standards 29 CFR 1910.157 and 1910.138. OSHA requires that personnel be trained in basic fire safety and that available fire fighting equipment is maintained. Also applicable are the Uniform Fire Code and the National Fire Protection Association (NFPA) Standards.

1.5.j Chemical Spill Response

Chemical spill response is addressed by OSHA in 29 CFR 1910.120, the Hazardous Waste Operations and Emergency Response Standard (HAZWOPER), which c an be found online at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9765), and the Laboratory Standard. Also, spill response is addressed in the Minnesota Hazardous Waste Rules.

1.6 CHEMICAL SAFETY IN OTHER ST. OLAF BUILDINGS

1.6.a The Dittmann Center and Speech Theater

1.6.b Other Buildings & Facilities Staff

CHAPTER 2

"Responsibilities"

"The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection: … 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).

"Responsibility for chemical hygiene rests at all levels including the: … Chief executive officer, … Supervisor of the department or other administrative unit, … Chemical hygiene officer, … Laboratory supervisor, … Project director or director of other specific operation, … [and] Laboratory worker."

29 CFR 1910.1450 Appendix A, Sec. B.

2.0 INTRODUCTION

This chapter identifies who is responsible to implement and enforce the various provisions of the St. Olaf Chemical Hygiene Plan & Laboratory Safety Manual (referred to as the "CHP"). In addition to developing some specific responsibilities, St. Olaf College has adopted the responsibilities listed for various personnel in Appendix A of the Laboratory Standard.

2.1 REVIEW AND EVALUATING THE CHEMICAL HYGIENE PLAN

2.1.a The CHP is reviewed annually by the CHO and updated, with input from the faculty, as needed.

2.2 RESPONSIBILITIES OF SPECIFIC INDIVIDUALS OR COMMITTEES

2.2.a General Responsibilities. The following general responsibilities apply to all individuals who work with, or in areas containing, hazardous chemicals:

(1) The responsibility for chemical hygiene and safety rests at **all** administrative and academic levels within St. Olaf College.

(2) **All** St. Olaf College faculty, staff, and employed student workers who work with chemicals are knowledgeable, respectful, and responsible in carrying out their duties in keeping safe all work areas where chemicals are used/stored.

(3) **Each person working with or around chemicals**, having been trained, **is responsible for remaining aware of the hazards of those materials and handling those chemicals in a safe manner**. All PELs and Action Levels must be followed.

(4) Each laboratory worker is responsible for knowing how to handle a hazardous chemical safely according to its types of hazards,

(5) Everyone shares the responsibility to ensure that all containers of chemicals are properly labeled with the identity of the chemical and its hazards.

(6) If you are unsure of a hazard or safety procedure, ASK!

(7) **Reporting an Unsafe Situation – all Persons**

(a) Faculty or staff may notice a questionable policy or practice of a member of an academic department. We want to maintain a healthy and safe environment at St. Olaf, and we ask all employees to be the eyes and ears of the Chemical Hygiene Committee.

(b) ***If you notice anything that you feel might represent an unsafe condition, <u>please</u> report immediately these conditions/concerns to the Chemical Hygiene Officer.***

(c) The CHO and ***St. Olaf College Chemical Hygiene Committee*** will then investigate thoroughly, and provide you with an explanation (written, if requested) of the findings and whatever corrective measures that are taken. In the unlikely event that you are worried about potential backlash from your report (which is an action that is not condoned by St. Olaf), you may instruct the CHO to file your report as anonymous.

2.2.b President of St. Olaf College

(1) *"Responsibility for chemical hygiene rests at al levels, including the Chief Executive Officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene."* 29 CFR 1910.1450 Appendix A, Sect. B.1.

(2) The Chief Executive Officer is Dr. David Anderson.

2.2.c Upper-level Administrators

(1) *Chain-of-Command inserted here*

(2) Promote the importance of safety in all activities.

(3) Promote the same attitude among all levels of employment at St. Olaf College.

(4) Support a broad-based laboratory safety/chemical hygiene program that will protect laboratory workers from health effects associated with hazardous chemical, biological, or physical agents.

(5) Ensure that Associate Deans provide adequate time and recognition for employees who are given laboratory safety responsibilities.

2.2.d Associate Dean

(1) Promote the importance of safety in all activities.
(2) Support a broad-based laboratory safety/chemical hygiene program that will protect laboratory workers from health effects associated with hazardous chemical, biological, or physical agents.
(3) Ensure that Department Chairs and Program Directors provide adequate time and recognition for employees who are given laboratory safety responsibilities.

2.2.e Department Chair or Program Director

(1) The "*Supervisor of the department or other administrative unit*" is *"responsible for chemical hygiene in that unit."* 29 CFR 1910.1450 Appendix A, Sect. B.2.
(2) Ensure that faculty, staff, and undergraduate research/teaching assistants adhere to the CHP and to accepted safety practices, and promote the importance of safety in all activities.
(3) Ensure that each laboratory has a specific person designated as the "Laboratory Supervisor" for the laboratory. This is especially important for labs that have many users, such as teaching labs or joint research labs.
(4) Support a broad-based laboratory safety/chemical hygiene program that will protect laboratory workers from health effects associated with hazardous chemical, biological, or physical agents.
(5) Ensure that Laboratory Supervisors, Faculty, and Stockroom Managers provide adequate time and recognition for employees who are given laboratory safety responsibilities.
(6) Appoint a departmental Health & Safety Committee.
(8) Work with faculty and staff to adapt the Chemical Hygiene Plan to include department- or lab- specific guidelines.
(9) Authority to Stop a Laboratory Activity. If ***the Department Chair or Program Director*** discovers a policy or observes conditions/practices that could result in unsafe chemical health & safety work conditions, then he/she ***has the explicit authority to suspend the practice/policy and refuse to allow employees to work in the particular location or perform a particular procedure until the problem is corrected.***
    (i) *Documentation*
    (ii) Appeals process

2.2.f Chemical Hygiene Officer (CHO)

(1) The **Chemical Hygiene Officer** for St. Olaf College is **Dr. Patrick Ceas**. Any questions concerning this Manual should be directed to him at 312 Regents Hall of Natural Sciences (RNS), 507-646-3560 (office), 507-321-0379 (cell), ceas@stolaf.edu.

(2) The St. Olaf CHO answers directly to the Assistant Provost (Dr. Arnie Ostebee).

(3) **Responsibilities as per the Laboratory Standard** (29 CFR 1910.1450 Appendix A, section B.3.)**:**

(a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and procedures.
(b) Monitor procurement, use, and disposal of chemicals.
(c) See that appropriate audits are maintained.
(d) Help project directors develop precautions and adequate facilities.
(e) Know the current legal requirements concerning regulated substances.
(f) Seek ways to improve the chemical hygiene program.

(4) **Additional Responsibilities & Authority of the St. Olaf CHO:**

(a) Ensure that the CHP is readily accessible to the employees.
(b) Ensure that provisions of the CHP are implemented in a timely manner.
(c) Develop and provide chemical hygiene safety/right-to-know information & training for faculty, staff and undergraduate research/teaching/stockroom assistants.
(d) Communicate regularly with the Stockroom managers to make sure that safety policies and procedures are being followed.
(e) Seek input from others when updating the training programs.
(f) Monitor the effectiveness of laboratory safety/right-to-know programs related to chemical safety; update the programs as needed.
(g) Ensure that annual departmental chemical inventories occur at least once per year (or more frequently if necessary).
(h) Advise project directors in the development of appropriate safety precautions for new projects and procedures.
(i) Ensure that appropriate personal protective equipment is available as needed.
(j) Conduct periodic walk-thru and audits of campus labs and facilities to ensure that safety and operating procedures detailed in the CHP are followed.
(k) Develop, implement, and monitor a chemical storage and hazardous waste management program with input from college staff.
(l) Generate hazardous waste manifests and contract reputable firms to dispose hazardous waste.
(m) Develop chemical hygiene policies and procedures, including regular yearly review and updates of the CHP, in accordance with all applicable governmental regulations.
(n) Maintain appropriate records related to the CHP.
(o) Provide chemical hygiene up-dates and reports to department chairs, facilities directors, and stockroom managers as needed.
(p) Investigate occupational accidents and illness related to chemical use.
(q) Determines when a complaint of possible over-exposure is "reasonable" and should be referred for medical consultation.
(r) Determines when an "Exposure Assessment" is appropriate.
(s) Monitor chemical hygiene expenditures.
(t) Review designs for construction or renovation of laboratories.

(u) Authority to Stop a Laboratory Activity. The CHO or CHO-designee is responsible for overseeing and enforcing all relevant federal and Minnesota state regulations pertaining to chemical hygiene and safety. ***If the CHO observes/becomes aware of a policy or practice that could result in unsafe chemical health & safety work conditions, then he/she has the explicit authority to suspend the practice/policy and refuse to allow employees to work in the particular location or perform a particular procedure until the problem is corrected.***

2.2.g Stockroom Managers

The stockroom managers for Chemistry, Biology, & Physics have unique roles and responsibilities because of their intimate daily dealings with hazardous chemicals, and their daily involvement with courses and project-related activities. Not only do these three persons oversee the ordering and storage of all chemicals used by workers within their academic departments, but they also supervise numerous undergraduate student teaching and/or stockroom assistants.

(1) The three Stockroom managers for the St. Olaf College FNSM academic programs are:
   (a) **Jodi Schmelz**, Chemistry, RNS 323, x3401, howem@stolaf.edu
   (b) **Dave Burton**, Biology & Psychology, RNS 323, x3393, burton@stolaf.edu
   (c) **Devin Lackie**, Physics, RNS 295A, x3121, lackie@stolaf.edu

(2) **Responsibilities of the Stockroom Managers:**
   (a) Monitor and procurement of all chemicals, including:
      (i) maintaining a current chemical inventory,
      (ii) determining proper storage requirements,
      (iii) filing the appropriate MSDS sheet,
   (b) Coordinate and monitor the collection and storage of chemical wastes.
   (c) Monitor proper functioning of protective equipment such as fume hoods, and assist in the prompt repair of faulty equipment.
   (d) Perform routine inspections of emergency equipment, ensure that all items are well marked and easily accessible, and make sure the equipment is in working order (the fire extinguishers are inspected and tested on a yearly basis by an outside company, so the Stockroom Manager needs only to ensure that the fire extinguishers are properly located and accessible in each room).
   (e) Ensure that all containers that leave the stockroom are properly labeled (see Section 7.4).
   (f) Ensure that undergraduate stockroom workers are knowledgeable, respectful, and responsible in carrying out their duties, and
   (g) Ensure that undergraduate stockroom workers are properly trained, and know and understand all relevant safety policies/procedures.

(3) Authority to Stop a Laboratory Activity. Because of their intimate awareness of the daily happenings in their respective departments relative to chemical use, if ***the Stockroom Manager*** discovers a policy or observes conditions/practices that could result in unsafe chemical health & safety work conditions, then he/she ***has the explicit authority to suspend the practice/policy and refuse to allow employees to work in the particular location or perform a particular procedure until the problem is corrected.***

(4) **Co-responsibilities of both the CHO & the Stockroom Managers:**
   (a) Remain current on developing legal rules and regulations concerning chemicals used at St. Olaf College.
   (b) Perform regular chemical hygiene and housekeeping inspections.
   (c) Review chemical inventory to assist the faculty in determining which chemicals are no longer needed and should be properly disposed.
   (d) Provide technical assistance in complying with the CHP and answer questions for employees.

2.2.h Laboratory Supervisor

(1) The Laboratory Supervisor *"has overall responsibility for chemical hygiene in the laboratory."*
29 CFR 1910.1450 Appendix A, Sect. B.4.

(2) **Who/What is a Laboratory Supervisor?**
   (a) Each Department has defined who/what is a Laboratory Supervisor.

(3) **Responsibilities as per the Laboratory Standard**: (29 CFR 1910.1450 Appendix A, Sect. B.4)
   (a) Ensure that workers know and follow the chemical hygiene rules.
   (b) Ensure that workers know and follow SOPs that are specific to that laboratory.
   (c) Identify the hazards in your laboratory, and determine the required levels of protective apparel and equipment.
   (d) Ensure that protective equipment is available and in working order.
   (e) Ensure that appropriate training has been provided.

(f) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (for emergency equipment, the Laboratory Supervisor needs only to ensure that all items are in the proper location, clearly marked, and easily accessible).
(g) Know the current legal requirements concerning regulated substances (i.e., attend training/information sessions given by the CHO; research the regulations for any hazardous chemical that used only by your laboratory).
(h) Ensure that facilities and training for use of any material being ordered are adequate.

(4) **Additional Responsibilities for St. Olaf Laboratory Supervisors:**
(a) Take responsibility, in attitude and action, for the safety conditions or your laboratory.
(b) Observe safety procedures and see that they are enforced.
(c) Set an example by wearing the appropriate PPE and by following proper laboratory procedures to promote safe work habits.
(d) Carefully review laboratory experiments for possible safety problems before the experiments are assigned to students.
(e) Make both preventive and remedial safety measures part of your instruction & research. Be sure students and lab workers are familiar with emergency procedures and equipment.
(f) Be alert for unsafe conditions. Inspect often; take corrective action promptly.
(g) Visitors and students are required to follow the same safety procedures as laboratory workers. If they refuse to follow the procedures, politely instruct them to leave the room; if they refuse then immediately contact the department chair, the CHO and campus security.
(h) Review and update (if necessary) procedure-specific SOPs at least annually or whenever conditions in the lab change.
(i) Material Safety Data Sheets and additional sources of info will be readily available to all individuals; encourage their use.

2.2.i Project Director or Director of Other Specific Operation

A laboratory that is under the direction of one Supervisor may be shared by more than one researcher/teacher ("Project Director"), and procedures specific to a subgroup of workers is not uncommon.

(1) The Project Director or immediate Supervisor of these subgroups:
(a) "*has primary responsibility for chemical hygiene procedures for that operation*."
29 CFR 1910.1450 Appendix A, sect. B.5.
(b) Will provide workers with <u>written</u> guidelines for SOPs that are specific to a particular procedure.
(c) Will ensure that workers know and follow SOPs that are specific to a particular procedure.

(d) Also, a person may be responsible for a "specific operation" such as the proper training and operation of the NMR equipment. This person will then have primary responsibility for chemical safety procedures related to that particular operation/equipment, etc.

2.2.j Laboratory Instructor

(1) Although the rules and regulations of the Laboratory Standard apply only to the college and its employees, St. Olaf College has chosen to go beyond the federal and state rules by creating an atmosphere of safety within the laboratory teaching environment.

(2) **Responsibilities for St. Olaf Laboratory Instructors:**
(a) Take responsibility, in attitude and action, for the safety conditions or your laboratory.
(b) Observe safety procedures and see that they are followed by your Teaching Assistant(s) and students.
(c) Set an example by wearing the appropriate PPE and by following proper laboratory procedures to promote safe work habits; ensure that students are wearing the appropriate PPE.
(d) Carefully review laboratory experiments for possible safety problems before the experiments are assigned to students.
(e) Make both preventive and remedial safety measures part of your instruction. Be sure students are familiar with emergency procedures and equipment.
(f) Be alert for unsafe conditions. Inspect often; take corrective action promptly.
(g) Visitors and students are required to follow the same safety procedures as laboratory workers. If they refuse to follow the procedures, politely instruct them to leave the room; if they refuse then immediately contact the department chair, the CHO and campus security.

(h) Review and update (if necessary) procedure-specific SOPs at least annually or whenever conditions in the lab change.
(i) Material Data Safety Sheets and additional sources of hazard information will be readily available to all students; encourage their use.

2.2.k Laboratory Workers - Faculty & Staff, and Research or Teaching Assistants

(1) **Responsibilities as per the Laboratory Standard** (29 CFR 1910.1450 Appendix A, sect. B.6.)
   (a) Plan and conduct each operation in accordance with the institutional chemical hygiene procedures.
   (b) Develop good personal chemical hygiene habits.
(2) **Additional Responsibilities for Laboratory Workers:**
   (a) Understand all training received; know and follow the rules & polices outlined in the CHP and further outlined for the specific laboratory.
   (b) Understand the function and proper use of all required PPE.
   (c) Wear PPE when mandated or necessary.
   (d) Report, in writing to your supervisor (who will forward the information to the CHO), any significant problems arising from the implementation of any standard operating procedure.
   (e) Accident Reporting. Report, in writing to your supervisor (who will forward the information to the CHO): all facts pertaining to every accident that results in exposure to toxic chemicals, and any action or condition that may exist that could result in an accident. Accident Reporting Forms can be found in Departmental offices.
   (f) Contact the Chemical Hygiene Officer if any of the above requirements are not clearly understood.

2.3.l St. Olaf Facilities Department – Chemical Safety-Related Repairs

It is recognized that the Facilities Department constantly receives requests & work orders for a tremendous variety of projects. It is also recognized and appreciated that the people who submit these work orders have every right to expect that their requests will be addressed in a timely manner. However, to ensure the health & safety of all employees, students, visitors, and the community at large, certain safety-related requests must take priority over non-safety requests, and in many cases must have an immediate response.

(1) **Requests for service involving the following engineering controls shall be given priority over non-safety work requests** by members of the St. Olaf community:
   (a) fume hood and ventilation problems (requires an immediate response)
   (b) safety shower and eyewash station problems (requires an immediate response)
   (c) gas lines
   (d) electrical problems/exposed wiring, etc.
(2) **Notification of on-duty mechanics & electricians.** In the event of an untimely equipment (e.g., hood) failure, the designated building facilities personnel must be notified immediately, and the problem must be addressed immediately. This requirement is especially important for RNS, where most of the hazardous chemicals are stored and used. Currently, Mark David (mechanic; 507-786-3280) and Larry Kiesler (electrician; 507-521-1929) are assigned to RNS.

   In the event either person is off duty on a particular day, the Assistant Director of Facilities will designate another facilities employee as the first contact person, and will notify the following persons that such a change has taken place:
   - Chemical Hygiene Officer
   - Stockroom Managers, Chemistry, Biology, & Physics
   - AAA, Chemistry, Biology, Physics
   - Appropriate Custodial Staff
   - Director, Public Safety

2.3.m St. Olaf Facilities Personnel

Facilities personnel often enter rooms that potentially contain hazardous chemicals, and some individuals (custodians) use chemicals on a daily or regular basis.

(1) St. Olaf Facilities staff members are required to read, understand, and follow all aspects of the Hazard Communication Program, and attend the annual training seminars given by the Director of Environmental Health and Safety.

2.2.n College Chemical Hygiene & Safety Committee *(this section under development)*

(1) The College Chemical Hygiene and Safety Committee (CHSC) is appointed by the President, and is a policy-based committee that assists and advises the CHO with the development, review, updating, and implementation of the St. Olaf Chemical Hygiene & Laboratory Safety Manual. This committee also has the authority to appoint subcommittees to address specific issues as needed.

(2) Members of the CHSC come from the following levels within St. Olaf College:
   - Chemical Hygiene Officer
   - Director, Public Safety
   - Director, Facilities
   - Department Representatives
   - Stockroom Managers (Chemistry, Biology/Psych, Physics, Art)
   - Facilities Staff Members
   - Student Representative(s)

2.3 Laboratory Construction and Renovation Projects

In order to ensure the safety of new and renovated laboratories, specific design and construction features are required by state and federal codes. All design, construction, and/or major modifications of laboratory facilities where hazardous chemicals are used or stored must be reviewed and approved by the (1) Director of Facilities, (2) Director of Environmental Health & Safety, and (3) Chemical Hygiene Officer.

CHAPTER 3

"Facilities"

This Chapter is under development

CHAPTER 4

"How You are Exposed to Chemicals,

and

Proper Steps to Avoid/Minimize Exposure "

"The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection: … Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals … including the use of personnel protective equipment and hygiene practices."

29 CFR 1910.1450(e)(3)(ii).

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

29 CFR 1910.1450(c)

"The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded."

29 CFR 1910.1450, Appendix A, Section A.5

4.0 INTRODUCTION

The primary goal of this Safety Manual is to provide policies and guidelines that, when properly followed, protect persons from harmful exposure to hazardous chemicals. This chapter will provide an overview of how you can be exposed to a chemical, and steps to take to avoid or minimize exposure to chemicals.

4.1 ROUTES OF EXPOSURE

If you understand how you can be exposed to chemicals then you can better protect yourself from becoming exposed. Exposure to chemicals can occur by four main routes: inhalation, contact with skin or eyes, ingestion, and injection.

4.1.a Inhalation. In addition to those substances that are in gas phase at ambient room temperature and pressure, many liquids and solids can give off harmful vapors or fumes. Also, fine powders can become airborne as dust particulates, and liquids can be shaken or atomized into a fine mist. Gases, Liquids, and Solids may also produce smoke when their vapors are ignited. If these substances are inhaled, the body can suffer physical damage to the mouth and respiratory system, or these substances can be absorbed into the blood and distributed to various internal organs.

4.1.b Contact with Skin or Eyes. In addition to being inhaled, vapors, fumes, or mists can come in contact with the skin or eyes and produce harmful results (think of how your eyes can water and hurt from simply peeling an onion). Chemicals obviously can come in direct contact with the body, so proper procedures and PPE must be used. Even if a chemical is not particularly harmful if it touches the skin, care must still be taken because the chemical can seep into the body through "insignificant" cuts in one's skin.

4.1.c Ingestion. Chemicals that are on a person's hands can be ingested if the person touches his/her mouth or contaminates food items with unwashed hands. Food items that are brought into a laboratory can absorb chemicals. Ingestion of chemicals should not occur if proper personal hygiene practices are followed.

4.1.d Injection. Chemicals that are on the surface of a sharp object (or an object that can be broken and stuck into the skin, such as a glass pipet), can be introduced into the body if the contaminated object accidentally penetrates the skin.

4.2 PROPER STEPS TO AVOID/MINIMIZE EXPOSURE TO CHEMICALS

To adversely affect a person, a chemical must come into contact with that person (i.e., the person must be exposed to the chemical). The four routes of exposures (inhalation, ingestion, injection, and eye/skin contact) limit the chemical's ability to contact us. If we properly protect ourselves, we can reduce or even eliminate the chance of exposure.

4.2.a The Basic Methods of Reducing Chemical Exposure. *The appropriate PPE shall always be worn while working with hazardous chemicals*, and *the proper Administrative Controls found in this safety manual shall be followed*. The preferred methods for reducing chemical exposure, in order of implementation, are:

(a) Substituting less hazardous materials or procedures,
(b) Using Engineering Controls (see Chapter 6)
(c) Using additional Personal Protective Equipment (i.e., PPE that is beyond the standard PPE)
(d) Implementing additional Administrative Controls as needed (e.g., modify an existing SOP or develop a new SOP).

4.2.b General Rules

(1) **Observe the Exposure Limits: PEL** (Permissible Exposure Limit), **TLV** (Threshold Limit Value), and **BEI** (Biological Exposure Indices). Substances can be hazardous simply by being exposed to the atmosphere because the harmful vapors can then come in contact with or be absorbed into a person's body. See Section 5.4 for further detail.
   (a) <u>If you are pregnant</u> here is a website with answers to many questions: http://www.dhs.ca.gov/ohb/HESIS/pregfs.htm
(2) **A fume hood or other containment device (glove box, etc.) must be used if exposure limits are likely to be exceeded** (see Chapter 6).
   (a) Because odor thresholds can be greater than the exposure limits, odors should not be used as the primary method of vapor detection.
   (b) If suspicious odors are noticed, the laboratory worker should obtain *mechanical vapor detectors*, such as detector tubes or ionization meters, and respiratory protection. Only persons who have received approved respirator training are authorized to wear respirators in the laboratory.
(3) Avoid inhalation of chemicals; do not "sniff" test chemicals.
   (a) If you need to smell a vapor do not put your nose directly above a flask, beaker, or other vessel that contains chemicals.
   (b) Holding the vessel at least one foot away, use you hand to gently and very cautiously fan the vapors towards your nose.
(4) Hold reagent bottles and other vessels containing liquids so that any drips will be opposite the label, and hold them so any previous drips on that same side do not get on your hand. Clean off any drips or spills.
(5) Avoid accidental injection of chemicals (be careful with sharp objects!).
(6) Never taste chemicals.
(7) Never use mouth suction to pipette chemicals; use suction bulbs or other mechanical devices.
(8) Only use glassware or utensils for their intended purposes (i.e., do not use a beaker as a drinking glass).
(9) Handle and store laboratory glassware with care to avoid damage. Inspect glassware often; do not use damaged glassware.
(10) Use extra precautions when handling containers that *are under negative or positive pressure*; shield or wrap them to contain chemicals and fragments should an explosion/implosion occur.
(11) Avoid practical jokes or other behavior that might confuse, startle, or distract another worker.
(12) Vent equipment that may discharge harmful vapors or mists (vacuum pumps, distillation columns) into fume hoods or snorkel hoods.
(13) Do not allow the release of toxic substances into cold rooms since these rooms recirculate the air.
(14) Immediately clean up all spills and properly dispose of the spilled chemical (see Chapter 12).
(15) **Never add water to acids or bases.** Dilute concentrated acids and bases by slowly pouring the acid or base into the water while stirring.
   (a) Combining acid and water frequently generates heat and may cause splashing.
   (b) Adding the acid to the water reduces the amount of heat generated at the point of mixing and provides more water to disperse the heat.

(16) **Benchtop Safety Shields.** Note that the use of a closed fume hood sash may suffice, but realize that there may be situations when a safety shield must be used inside a fume hood. The shield must be placed between the apparatus and the worker. These shields (in addition to chemical splash-resistant goggles) must be used when:
   (a) A higher-than-normal splash hazard exists (e.g., heating concentrated corrosives).
   (b) The contents are under a sufficiently strong positive or negative pressure that, should the vessel break, debris from an unprotected container could be projected about the lab.

(17) Radios, MP3 players, mobile telephones, and other personal audio devices have the potential to distract attention from experimental work and are therefore not permitted to be used in teaching labs.

4.2.c Personal Clothing, Jewelry, and Hair

The most fundamental piece of protective clothing is provided by each employee. It is the normal personal clothing worn in the laboratory. Clothing should be worn to minimize exposed skin surfaces available for direct contact through splashing.

(1) **Shoes**. Low-heeled shoes with fully closed tops/heels must be worn in laboratories, regardless of the work that is occurring.
   (a) Open-toe (or perforated) shoes or sandals do not provide protection from chemical splashes, spills, falling objects, and materials hidden in the toe space along bench areas.
   (b) Shoes with tops and sides made of leather, synthetic leather, or other liquid-resistant materials uppers are preferred and may be required during certain lab procedures.
   (c) Cloth/canvas materials can allow liquids to quickly seep through to the foot and must not be worn.
   (d) Faculty or departmental staff who observe others wearing inappropriate footwear have the authority to tell the individuals to change their shoes before being permitted to work in the laboratory.

(2) **Clothing.** Wear clothing that provides protection from chemical spills; launder work clothes often and separately from other clothes.
   (a) Clothing that completely covers the legs must be worn at all times. Shorts and skirts that do not completely cover the leg are inappropriate apparel in the laboratory and are not permitted.
   (b) Do not wear open-backed shirts, bare midriff shirts, or shirts that expose areas of the torso in the laboratory.
   (e) Clothing with loose portions, such as open sweaters, baggy cuffs or sleeves, or hanging scarves should not be worn since they may catch on glassware and equipment, may drag through spills, and in some cases may be a fire hazard.

(3) **Hair.** Loose long hair (i.e., longer than shoulder length) should be tied back so that it does not become entangled with equipment, exposed to chemicals, or provide an impediment to vision.

(4) **Jewelry.** It is best to not wear any jewelry while in a laboratory. Dangling jewelry can become entangled in equipment and can conduct electricity. Chemicals can become trapped under the jewelry and cause injuries to the skin.

(5) Avoid wearing synthetic fingernails in the laboratory. Synthetic fingernails are made of extremely flammable polymers that can burn to completion and are not easily extinguished.

(6) **Contact lenses.** Contact lenses can be worn, but appropriate chemical splash resistant goggles must also be worn as required (See Section 4.2.d(2)).

4.2.d Personal Protective Equipment (PPE)

> Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be … used … wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.
>
> 29 CFR 1910.132

(1) **Hazard Assesment.** St. Olaf College provides most personal protective equipment to employees when and where necessary. It is the responsibility of each employee to be certain that the appropriate equipment is worn as necessary.
   (a) The Laboratory Supervisor (using the Laboratory Inspection Sheet) will conduct periodic assessments of laboratory workplaces to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE).

(b) If such hazards are present or likely to be present, the Laboratory Supervisor (in consultation with the CHO) will select the type(s) of PPE, Administrative Controls, Engineering Controls, etc. that will protect affected individuals from the hazards, and will report to the departmental Chemical Health & Safety Committee on a regular basis with his/her findings.

(2) **Chemical-resistant Splash Goggles** (conforming to Type H in ANSI Z 87.1-2003 *Occupational and Educational Personal Eye and Face Protection Devices*) **must be worn by all individuals** (including visitors) **if any of the following conditions exist**:

(a) Hazardous substances are in use.

(b) Hazardous substances are not stored behind closed doors in designated cabinets (i.e., containers sitting on countertops; bottles being transported, etc.).

(c) Performing procedures that involve an open flame or sparks.

(d) Using equipment that is under sufficient negative or positive pressure as to create a risk of flying material should the container break (a portable safety shield is also required in such circumstances). The ANSI Type H goggles are also impact-resistant, so the same goggles that you use as chemical safety will also be used for these procedures.

(e) The Chemistry Department sells a couple of styles of Type H goggles. If these goggles do not provide a satisfactory fit then you can purchase goggles from a number of commercial distributors, such as http://www.labsafety.com or https://www1.fishersci.com/.

(f) Chemical splash goggles do not need to be worn if the laboratory instructor/supervisor or Department has concluded that no chemical hazard exists. Each department maintains a list of laboratories/lab sessions that meet this requirement.

(3) **Gloves.** Disposable nitrile gloves are provided to all users, but you must wear gloves that are known to be resistant to permeation by the substances in use. To ensure that you are wearing a glove that has the appropriate degradation and permeation characteristics it is best to consult the compatibility charts for the manufacturer of the glove being used.

(a) Two websites that have links to many glove manufacturers can be found at http://www.hazmat.msu.edu:591/glove_guide/ and http://www.ehs.ufl.edu/lab/chp/gloves.htm.

(b) Inspect the gloves for defects before wearing (inflate by whipping in air, not by mouth inflation) and periodically during use.

(c) Replace damaged or contaminated gloves immediately.

(d) Remove your gloves before operating computers instrumentation, etc. in the laboratory; wipe off surfaces when finished.

(e) Remove your gloves before exiting the laboratory and discard them in the appropriate waste container in order to prevent unintentional contamination of doorknobs, telephones, computer keyboards, etc.

(f) **Temperature Extremes**. Heat or cold-resistant gloves must be used if handling containers that are hot or cold enough to damage one's hands on contact.

(4) **Laboratory Coats** or chemically-resistant laboratory aprons are strongly recommended and may be required by your laboratory supervisor.

(5) **Laboratory Aprons** (rubberized) offer additional protection in the event of a chemical spill or splash.

(6) **Face Shields.** For more hazardous chemicals, concentrated corrosives, and hot chemicals, both face shield and chemical splash goggles must be used.

(7) Ear protection must be worn when needed in compliance with 29 CFR 1926.52.

(8) **Respiratory Protection**. The use of air purifying respirators for routine laboratory work is not recommended since they protect only the wearer, and require periodic medical monitoring, specific training, and fit testing before they can be worn effectively. If the use of a respirator is necessary to maintain exposure below PELs, St. Olaf College will provide, at no cost to the employee, the proper respiratory training and equipment as per 29 CF 1910.134, and outlined in the the St. Olaf College Respirator Protection Program.

(9) **Fume Hoods** and other Engineering Controls are discussed in Chapter 6.

4.2.e Personal Hygiene

(1) Wash immediately and thoroughly if a chemical has contacted the skin.

(2) Wash well before leaving the laboratory (wash your hands and arms, even if you were wearing gloves). Do not wash with solvents; use soap.

(3) Do not handle your contact lenses while in the laboratory, and handle them outside of lab only after thoroughly washing your hands.

(4) Do not wipe your hands on your pants, shirt, or lab coat; use a paper towel.

4.3 ENVIRONMENTAL MONITORING

Environmental monitoring will be conducted when an employee reasonably suspects that he/she has sustained an exposure to a hazardous chemical exceeding the PEL or Action Level for a regulated substance. If this initial monitoring indicates that exposure over the action level or PEL is exceeded then the provisions of the relevant OSHA standard become effective. Monitoring may be terminated in accordance with the relevant standard. The employee will be notified of monitoring results within 15 working days of the receipt of the results by the Chemical Hygiene Officer.

CHAPTER 5

"How Do I Know if a Chemical is Hazardous, and How Do I Learn About Its Hazardous Characteristics?"

5.0 INTRODUCTION & DEFINITION OF "HAZARDOUS CHEMICAL"

5.0.a Introduction. There are over 500,000 substances that fit the OSHA definition of "hazardous chemical." The remaining sections of this chapter will help you to determine if a chemical should be considered hazardous – ***use all sections of Chapter 5 regularly, and do not rely solely on one source of information to learn about a chemical's hazard characteristics.***

5.0.b Definition of "Hazardous Chemical"

(1) The OSHA Laboratory Standard defines 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 principles that acute or chronic health effects may occur in exposed employees"
(29 CFR 1910.1450(b)).

(2) **A Chemical is considered hazardous if it is found on any of the lists of chemicals presented in Section 5.3, or if its NFPA rating is ≥ 1 (Section 5.5).**

5.1 OSHA CATEGORIES OF HAZARDOUS CHEMICALS

(OSHA divides hazardous chemicals into "physical" or "health" hazards. The worker should be aware that it is possible that a substance may be both a potential physical and health hazard.)

5.1.a Physical Hazards

The OSHA Laboratory Standard (29CFR 1910.1450(b)) considers a chemical a physical hazard if it falls into one of the following categories. Refer to Section 8.2-8.11 for Definitions and SOPS.

(1) Oxidizers (Section 8.2)
(2) Combustible Liquids, or Flammables (Section 8.3)
(3) Explosives (Section 8.4)
  (a) Shock- Sensitive (Section 8.4)
  (b) Organic Peroxides & Peroxide-Forming Substances (Section 8.5)
  (c) Dusts, Explosive Boiling (Section 8.6)
(4) Reactives
  (a) Incompatibles (Section 8.7)
  (b) Pyrophorics (Section 8.8)
  (c) Water-Reactives (Section 8.9)
(5) Compressed Gases (Section 8.10)
(6) Cryogens and Liquified Gases (Section 8.11).

5.1.b Health Hazards

The OSHA Laboratory Standard (29 CFR 1910.145(b)) considers a chemical a health hazard if it falls into one of the following categories. Refer to Section 8.12-8.17 for Definitions and SOPs.

(1) Corrosives (Section 8.12)
(2) Irritants (Section 8.13)
(3) Sensitizers & Allergens (Section 8.14)
(4) Asphyxiants (Section 8.15).
(5) Hepatotoxins (Section 8.16)
(6) Carcinogens (Section 8.17)
(7) Toxic or Highly Toxic Substances (Section 8.17)
(8) Reproductive Toxins (Section 8.17)
(9) Agents which act on the hemotopoietic systems (various sections)
(10) Agents which damage the lungs, skin, eyes, or mucous membranes (various sections)

5.1.c Health Hazards – Additional Information

Prior to using substances classified as health hazards, it is essential that the risks associated with these chemicals be well understood:

(1) All such substances can potentially have adverse effects on living systems depending on the duration of exposure, frequency of exposure and the inherent toxicity of the particularsubstance.
(2) Toxic effects can be acute, causing damage after a single short duration exposure, or chronic, causing damage either after repeated or long duration exposure or a long latency period. Some chemical s may have both acute and chronic toxic effects.

(3) It is highly possible that a specific chemical may exhibit several adverse health effects, and it is then necessary to consult all appropriate procedures.
(4) **It is the responsibility of the Laboratory Supervisor to ensure that the PEL,TLV, or Action Level (Section 5.4) for a specific chemical is not exceeded.**

5.1.d Particularly Hazardous Substances

The OSHA Laboratory Stand (29 CFR 1910.14450(e)(3)(vii)) considers certain classes of Health Hazards to be "Particularly Hazardous." These three classes of substances are 'Select Carcinogens,' 'Reproductive Toxins,' and 'Substances that have a High Degree of Acute Toxicity.' Provisions for additional protection for personnel working with these substances are required. Refer to Section 8.17 for Definitions & SOPs.

5.2 Basic Steps to Determine a Chemical's Hazard Characteristics and the Associated Handling Risks

The following outline and sets of questions (modified from *"Prudent Practices"* – see Section 7.2 for more information about this reference) provide a summary of the steps that laboratory workers should use to assess the hazardous characteristics the risks of handling chemicals.

5.2.a Identify Chemicals to be Used and Circumstances of Use.

(1) Determine the amounts that will be used.
(2) Is the experiment to be done once, or will the chemicals be handled repeatedly?
(3) Will the experiment be conducted in an open laboratory, in an enclosed apparatus, or in a fume hood?
(4) Is it possible that new or unknown substances will be generated in the experiment?
(5) Are any of the workers involved in the experiment pregnant or likely to become pregnant?
(6) Do any of the workers have any known sensitivities to specific chemicals?

5.2.b Determine if a Chemical and Resulting Waste Products are Hazardous.

(1) See Section 5.3, 5.5, and (for wastes) Section 12.3.
(2) In cases where substances with significant or unusual potential hazards are involved, it may also be advisable to consult more detailed references such as Mackison et al. (U.S. DHHS, 1981), Patnaik (1992), Patty's (Clayton and Clayton, 1993), and other sources discussed in Section 3.B of *Prudent Practices*.
(3) Depending on the worker's level of experience and the degree of potential hazard associated with the proposed experiment, it may also be necessary to obtain the assistance of supervisors, the Chemical Hygiene Officer, and other safety professionals before proceeding with risk assessment (sections 5.2.c-g).

5.2.c Evaluate Type of Toxicity/Hazard Characteristics.

(1) Realize that no single reference is all-inclusive, and different persons have different preferences for accessing information; therefore, users are strongly encouraged to use multiple sources of information, many which are discussed in Sections 5.3.b – 5.11.
(2) Are any of the chemicals to be used acutely toxic or corrosive?
(3) Will any Select Carcinogens or possibly carcinogenic substances be encountered?
(4) For many substances, it will be necessary to consult the listings of carcinogens to identify chemical similarities to known carcinogens (See Table 3.5 of *Prudent Practices* for Classes of Carcinogenic Substances - http://darwin.nap.edu/books/0309052297/html/45.html).
(5) Are any chemicals involved in the proposed experiment suspected to be reproductive or developmental toxins or neurotoxins?

5.2.d Consider Possible Routes of Exposure.

(1) Are the chemicals gases, or are they volatile enough to present a significant risk of exposure through inhalation?
(2) If the substance is liquid, can it be absorbed through the skin?
(3) Is it possible that dusts or aerosols will be formed in the experiment?
(4) Does the experiment involve a significant risk of inadvertent ingestion or injection of chemicals?

5.2.e Evaluate Quantitative Information on Toxicity.

(1) Determine the LD_{50} for each chemical via the relevant routes of exposure.
(2) Determine the acute toxicity hazard level for each substance, classifying each chemical as highly toxic, moderately toxic, slightly toxic, and so forth.
(3) Follow the threshold limit value time-weighted average (TLV-TWA), short-term exposure limit (STEL), and permissible exposure limit (PEL) values (see Section 5.4).

5.2.f Select Appropriate Procedures to Minimize Exposure.

(1) Use the "Basic Rules and Procedures for Handling Chemicals" (Chapter 7) for all work with chemicals in the laboratory.
(2) Follow the hazard-specific procedures presented in Chapter 8.
(3) Determine whether any of the chemicals to be handled in the planned experiment meet the definition of a Particularly Hazardous Substance due to high acute toxicity, carcinogenicity, and/ or reproductive toxicity (Section 8.17).
    (a) If so, then consider the total amount of the substance that will be used, the expected frequency of use, the chemical's routes of exposure, and the circumstances of its use in the proposed experiment.
    (b) Use this information to determine whether it is appropriate to apply the additional procedures for work with highly toxic substances and whether additional consultation with safety professionals is warranted.

5.2.g Prepare for Contingencies.

(1) Note the signs and symptoms of exposure to the chemicals to be used in the proposed experiment.
(2) Be familiar with the appropriate measures to be taken in the event of exposure or accidental release of any of the chemicals.

5.3 ONLINE LISTS OF HAZARDOUS CHEMICALS

5.3.a OSHA and Minnesota Lists of Hazardous Chemicals.

These websites are simply lists of the chemicals. **If your chemical is included on one of these lists then you must treat it as a hazardous chemical**. Except for item #5, the lists in Section 5.3.a do not contain specific information on the hazards, and are merely included to provide a quick reference starting point.

(1) **OSHA Master List**. The OSHA list of Hazardous Chemicals can be found online at http://www.cdc.gov/od/ohs/manual/chemical/chmsfapp2.htm#osha2.
(2) **Minnesota Master List**. The Minnesota Department of Labor list of hazardous substances can be found in Minnesota Rules 5206.0400 and online at http://www.revisor.leg.state.mn.us/arule/5206/0400.html. In general, it contains the majority of hazardous substances that will be encountered in Minnesota; however, the user must realize that it does not include all hazardous substances and may not always be current. This is also simply a list of the chemicals, and does not contain specific information on the hazards.
(3) **OSHA List of Reproductive Toxins and Highly Acute Toxic Materials** http://www.cdc.gov/od/ohs/manual/chemical/chmsfapp2.htm#toxin.
(4) **OSHA List of Select Carcinogens** (see also Section 8.17.a(1)) http://www.cdc.gov/od/ohs/manual/chemical/chmsfapp2.htm#osha.
(5) **OSHA List of Extremely Hazardous Chemicals** http://yosemite.epa.gov/oswer/ceppoehs.nsf/Alphabetical_Results?openview.

5.3.b Searchable Lists that Contain Hazard Information.

(1) **University of Minnesota List of Substances and Their Hazardous Characteristics** http://www.dehs.umn.edu/safety/lsp/AppB.html.
This downloadable and extremely useful Excel file contains the following information for over 2700 substances: OSHA & ACGIH exposure limits, odor limits, EPA categories of carcinogens, NFPA ratings, and Immediately Dangerous to Life and Health (IDLH) concentrations.
(2) **OSHA/NIOSH/DOE Health Guidelines.** http://www.osha.gov/SLTC/healthguidelines/.

This multiuse website summarizes pertinent information about numerous chemicals, including health hazard ratings, PPE requirements, emergency medical procedures, storage requirements, and spill cleanup.

(3) **OSHA Chemical Sampling Information Pages.**
http://www.osha.gov/dts/chemicalsampling/toc/toc_chemsamp.html.
This website is used by OSHA personnel. It includes Exposure Limits, health factors, and monitoring methods.

5.3.c The "Dirty Dozen"

According to "Prudent Practices" it is generally recognized that certain substances in research laboratories tend to be responsible for "more than their share of accidents." These substances have earned the nickname of the "Dirty Dozen" and are listed below:

(1)

Substance	Hazard
(a) Organic azides	Explosion hazards, especially with ground glass joints
(b) Perchlorate salts of organic, organometallic, & inorganic complexes	Explosion hazards
(c) Diethyl ether	Fires (see also entry j below)
(d) Lithium aluminum hydride	Fires on quenching
(e) Sodium, potassium	Fires on quenching
(f) Potassium metal	Fires on quenching
(g) Sodium-benzophenone ketyl still pots	Fires on quenching
(h) Palladium on carbon	Fires on removal from the inert atmosphere, especially if wet with organic solvent or when contacting combustible materials such as filter paper
(i) Heat	Exothermic reactions causing violent spills on scale-up due to inadequate provision for heat removal
(j) Ethers with α-hydrogen atom	Dangerous peroxide concentration during distillation; explosion hazards, especially with ground glass joints
(k) Carbon monoxide	Toxicity and role in forming nickel tetracarbonyl from steel gas lines and autoclaves
(l) Organic peroxides	Sensitivity to shock, sparks, and other forms of accidental detonation; sensitivity to heat, friction, impact, and light, as well as to strong oxidizing and reducing agents

(2) **Develop your own lab-specific "Dirty Dozen."** Inappropriate mixing or handling of certain compounds can also produce hazardous toxic gases. Individual laboratories are encouraged to prepare their own list of additional "Dirty Dozen" substances as part of their laboratory-specific Standard Operating Procedures.

5.4 OSHA PERMISSIBLE EXPOSURE LIMITS & ACTION LEVELS: YOU MUST FOLLOW THESE LIMITS

Substances can be hazardous simply by being exposed to the atmosphere because the harmful vapors can then come in contact with or be absorbed into a person's body. Therefore, most substances have some guidelines for exposure, such as ACGIH's Threshold Limit Values (TLV), or OSHA's Permissible Exposure Limits (PEL).

5.4.a OSHA PELs. OSHA (29 CFR part 1910 subpart Z) sets PELs to protect workers against the health effects of exposure to hazardous substances. The PELs are limits on the amount or concentration of a substance in the air, and they may also contain a skin designation. The basic exposure limits are defined as the concentration of a chemical in air to which nearly all individuals can be exposed without adverse effects for an 8-hour work-day over a 30 year career. The numbers are usually expressed in parts per million (ppm) or mg/m^3.

(1) The PELs (found in Table Z-1of 29 CFR part 1910.1000) are measured in one of two ways:

(a) Ceiling Values. An employee's exposure to any substance in Table Z-1, the exposure limit of which is preceded by a "C", shall at no time exceed the exposure limit given for that substance. If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute time weighted average exposure which shall not be exceeded at any time during the working day.

(b) 8-hour Time Weighted Averages. An employee's exposure to any substance in Table Z-1, the exposure limit of which is not preceded by a "C", shall not exceed the 8-hour Time Weighted Average given for that substance in any 8-hour work shift of a 40-hour work week.

(c) Short Term Exposure Limits (STEL). For a select subset of chemicals, OSHA has set "acceptable maximum peak" concentrations that may not be exceeded for short time periods (from 4 - 30 minutes). This list of chemicals and the corresponding STEL can be foundin Table Z-2 of 29 CFR part 1910.1000.

(2) **The PELs are** regulatory in nature and **enforceable**. They **must be followed**.

(3) The OSHA PELs can be found online at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992.

5.4.b OSHA Action Levels. An Action Level, calculated as an eight (8)-hour time-weighted average (and generally lower than the PEL), is a concentration designated for specific substances listed in 29 CFR part 1910 that initiates certain required activities such as exposure monitoring and medical surveillance. For example, the PEL for lead is $50ug/m^3$ while the Action Level is $30ug/m^3$. **Actions Levels must be followed**.

5.4.c ACGIH Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). ISBN 1-882417-49-6

The American Conference of Governmental Industrial Hygienists (ACGIH; http://www.acgih.org) is "an organization devoted to the administrative and technical aspects of occupational and environmental health." The TLVs and BEIs were developed by the ACGIH to "recommend airborne concentrations of agents and exposure conditions for use in the practice of industrial hygiene and by other qualified professionals to protect worker health."

(1) **TLVs** and **BEIs** are not regulatory standards, but since they are updated annually **St. Olaf College laboratory employees are expected to follow these** if the limits are more restrictive than the PELs.

(2) The TLVs and BEIs are not available online.
Hard copies are located in the Biology & Chemistry stockrooms, and in the Chemical Hygiene Office.

5.4.c Use a Fume Hood if the TLV or PEL is below 50 ppm or 100 mg/m^3.

4 Below 22.8°C
3 Below 37.8°C
2 At or Above 37.8°C
Below 93.4 °C
1 At or Above 93.4°C

5.5 USING THE NFPA HAZARD DIAMOND

Chemicals in the St. Olaf College laboratory facilities, whether in the original container or in a secondary container, display (if necessary) a multicolored sticker or emblem that is inscribed with numbers and possibly letters. This sticker is normally in the shape of a diamond (consisting of four smaller diamonds), and represents the NFPA (National Fire Protection Agency) Hazard Identification System (NFPA 704; 2001).

5.5.a A chemical will be considered hazardous, and all appropriate safeguards must be used, if the NFPA Diamond:
(1) **has any lettering in the "White" section (i.e., the lower or "southern" section), or**
(2) **contains a number '1' or greater in any of the three remaining colored sections**

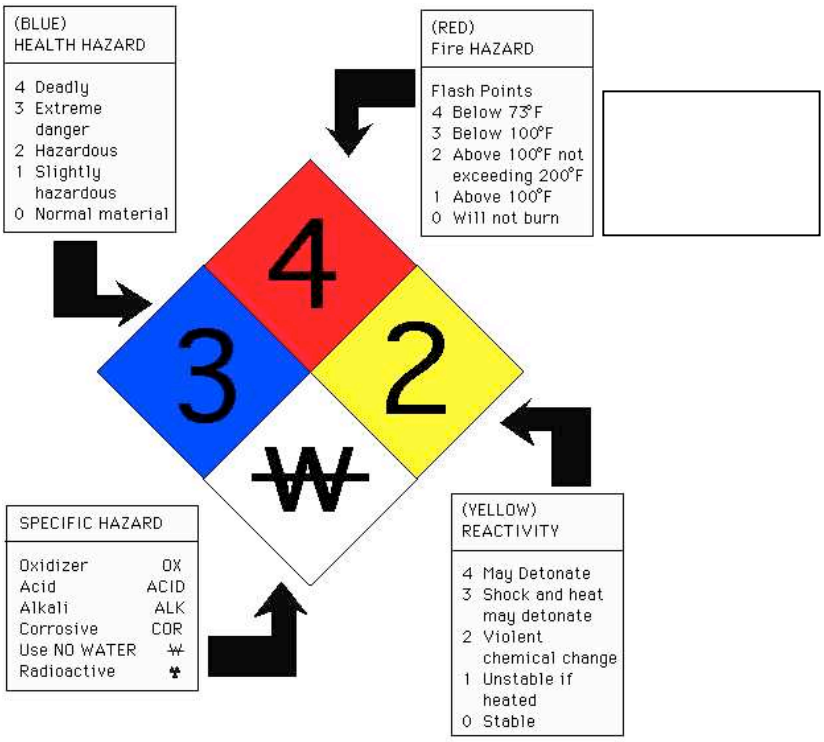
5.5.b A chemical will be handled with extreme care if the NFPA rating is a '3' or '4'

5.5.c *Although it is possible to assess the initial hazards of a chemical by examining the NFPA Diamond,* ***other sources of information must be consulted before using a chemical that is considered hazardous****. These sources are discussed in the various Sections of Chapter 5.*

5.5.d The NFPA ratings for numerous chemicals are available online at many sites. Three easy-to-use sites are:
(1) http://www.dehs.umn.edu/safety/lsp/appendixB.xls
(2) http://www.hazmat.msu.edu:591/nfpa
(3) http://www.nmsu.edu/~safety/programs/chem_safety/NFPA-ratingA-C.htm

5.5.e The NFPA Diamond – Hazard Ratings.
The four colored regions correspond to a chemical's Fire (Red), Reactivity/Instability (Yellow), Health (Blue), or "Special" (White) hazards, and the number within a particular region indicates the hazard level associated with that category. A larger number indicates a greater potential hazard. The four regions are always arranged in the same order. Detailed explanations of each category are provided on the next page.

NFPA Classification System
(NFPA 704; 2001)



5.5.f The NFPA Diamond – Basic Criteria.

(1) **Flammability Hazard Ratings**

(a) **0** Substance **will not burn** under typical fire conditions.

(b) **1** **Flashpoint ≥ 93.4°C (200°F)**
(= Class IIIB liquids)
Substance requires considerable preheating, under ambient temperature conditions, before ignition and combustion can occur.

(c) **2** **93.4°C > Flashpoint ≥ 37.8°C**
200°F > Flashpoint ≥ 100°F
(= Class II and IIIA liquids)
Substance must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.

(d) **3** **37.8°C > Flashpoint ≥ 22.8°C** **or [(22.8°C > Flashpoint) and (Boiling Point ≥ 37.8°C)]**
(= Class IB and IC liquids)
100°F > Flashpoint ≥ 73°F **or [(73°F > Flashpoint) and (Boiling Point ≥ 100°F)]**
Substance can be readily ignited under almost all ambient temperature conditions.

(e) **4** **22.8°C > Flashpoint and 37.8°C > Boiling Point**
73°F > Flashpoint and 100°F > Boiling Point
Flammable Gases
Materials that ignite spontaneously when exposed to air
(= Class IA liquids)
Substance will rapidly or completely vaporize at ambient temperature and will burn readily.

(2) **Health Hazard Ratings**

(a) **0** Exposure under emergency conditions would offer no hazard beyond that of ordinary combustible materials.

(b) **1** Exposure under emergency conditions could cause significant irritation.

(c) **2** Exposure under emergency conditions could cause temporary incapacitation or possible residual injury.

(d) **3** Exposure under emergency conditions could cause serious temporary or residual injury even though prompt medical attention was given.

(e) **4** Very short exposure could cause death or serious residual injury even though prompt medical attention was given.

(3) **Reactivity or Instability Hazard Ratings**

(a) **0** Normally stable, even under fire exposure conditions, and are not reactive with water.

(b) **1** Normally stable, but can become unstable at elevated temperatures and pressures or may react with water with some release of energy, but not violently.

(c) **2** Normally unstable and readily undergo violent chemical change at elevated temperatures and pressures, but do not detonate. Also: may react violently with water or may form potentially explosive mixtures with water.

(d) **3** Capable of detonation or explosive reaction, but requires a strong initiating source or must be heated under confinement before initiation, or reacts explosively with water.

(e) **4** Readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.

(4) **Special Hazard Ratings** There are only two approved NFPA symbols (OX and ~~W~~), but all of the following symbols are normally used:

(a) **OX** Denotes an oxidizer, a chemical which can greatly increase the rate of combustion/fire.

(b) **~~W~~** Unusual reactivity with water. This indicates a potential hazard using water to fight a fire involving this material.

(c) **ACID** Denotes an acid, a corrosive material that has a pH < 7.0

(d) **ALK** Denotes an alkaline material, also called a base. These caustic materials have a pH > 7.0

(e) **COR** Denotes a material that is corrosive (it could be either an acid or a base).

(f) **The Skull & Crossbones** is used to denote a poison or highly toxic substance.

(g) The international symbol for **Radioactivity** is used to denote radioactive hazards; radioactive materials are extremely hazardous when inhaled.

5.6 USING MATERIAL DATA SAFETY SHEETS (MSDSS)

A Material Safety Data Sheet (MSDS) is a document supplied by a chemical manufacturer that contains relevant safety information. An MSDS is designed to provide laboratory and emergency personnel with the proper procedures for handling, storage, and disposal of a particular hazardous substance. MSDSs are written for a large audience, including workers in industrial as well as laboratory fields, and employees should realize that the quality and completeness of information on MSDSs can vary among suppliers.

Within RNS, MSDSs for all chemicals in a particular laboratory or storage area have been placed in a three-ring binder in each teaching laboratory, and the binder is labeled with highly visible signage. The MSDSs are also available online (See Section 5.6.b).

5.6.a The Sections of an MSDS. For consistency purposes, a 16-section standard format has been established by the American National Standards Institute (ANSI Z400.1-1998):

(1) **Product Identification**
Provides information about the chemical and supplier, including:
- Synonyms
- CAS Number
- Molecular weight
- Chemical formula

(2) **Composition/Information on Ingredients**
- Ingredients

(3) **Hazards Identification**
- Emergency Overview
- Protective Equipment needed
- Route of Entry
- NFPA Hazard Ratings
- Potential Health Affects

(4) **First Aid Measures**
- Inhalation
- Ingestion
- Notes to Physician
- Skin Contact
- Eye Contact

(5) **Fire Fighting Measures**
- Flash Point
- Lower Explosion Limts
- Fire extinguishing media
- Special information

(6) **Accidental Release Measures**
- Actions that should be taken in the event of an accidental release/spill of the material

(7) **Handling and Storage**
- Information on how to safely handle and store the material

(8) **Exposure Controls and Personal Protection**
- Airborne exposure limits (PELs, TLVs)
- Ventilation system requirements
- Personal respirator requirements
- Eye protection
- Skin protection

(9) **Physical and Chemical Properties**
- Appearance
- Odor
- Solubility
- Specific Gravity
- Boiling point
- Melting point
- Vapor density
- Evaporation rate
- pH
- Vapor pressure

(10) **Stability and Reactivity**
- Hazardous decomposition products
- Hzardous polymerization
- Incompatibles
- Conditions to avoid

(11) **Toxicological Information**
- LD_{50} information, carinogens, etc.

(12) **Ecological Information**
- Environmental fate, tocity

(13) **Disposal Considerations**
- Recommended disposal methods

(14) **Transport Information**
- Shipping classification

(15) **Regulatory Information**
- Federal, state, and international regulations

(16) **Additional Information**
- Label precautions
- Product use
- Revision information
- Disclaimer

5.6.b Online links to Material Safety Data Sheets

MSDSs are available free at many Websites, or you can often go directly to the manufacturer's own website. Among the most comprehensive sites are:

(1) http://www.pp.okstate.edu/ehs/LINKS/msds.htm (Oklahoma State, contains numerous links)
(2) http://hazard.com/msds/index.php (Vermont SIRI)
(3) http://msds.ehs.cornell.edu/msdssrch.asp (Cornell University)
(4) http://www.msdsonline.com/ (MSDS Online)
(5) http://www.msds.com/ (MSDS Solutions)
(6) http://www.chemexper.com/ (ChemExper)
(7) http://www.setonresourcecenter.com/MSDSs/comply1.htm (Seton)

5.7 USING THE CHEMISTRY LABORATORY INFORMATION PROFILES ('CLIPS')

5.7.a These very informative profiles are written by Dr. Jay Young for the Journal of Chemical Education, American Chemical Society. There are over 60 profiles of commonly used chemicals currently available.

(1) **Why use CLIPs?** (wording taken from Dr. Young's Introduction on the ACS website):
   (a) Many MSDSs and labels do not directly apply to the use of chemicals in the instructional laboratory. They are written for industrial use where the procedures involve large quantities of chemicals in multi-gallon sized vessels connected one to another by piping equipped with valves requiring electric-powered motors to open and close.
   (b) Although it is less common today than it was a few years ago, some MSDSs do not disclose all of the information required by the pertinent OSHA regulation, 29 CFR 1910.1200.
   (c) CLIPs can be used to assist your determinations of the precautions your students should take in their laboratory work, or they can be used to guide students in discussions wherein they participate in selecting the precautionary measures for their own laboratory work.
   (d) Also, using a few published CLIPs as examples, students could be assigned the task of preparing their own CLIPs for one or more of the reagents to be used in next week's laboratory work. Other pedagogic applications are possible.

(2) CLIPS can be viewed online at http://membership.acs.org/c/ccs/pubs/CLIPS/default.htm.

5.8 USING THE LABORATORY CHEMICAL SAFETY SUMMARIES (*PRUDENT PRACTICES*)

5.8.a As stated in *Prudent Practices*, "The LCSSs provide concise critical discussions of the toxicity, flammability, reactivity, and explosibility of 88 chemicals commonly used in scientific research laboratories. Directions for handling, storage, and disposal and special instructions for first aid and emergency response are given. Since many of these 88 chemicals are representative of a class of potentially hazardous compounds, the LCSSs can also be used as guides to handling many other compounds with related chemical structures."

(1) LCSSs can be viewed online at http://www.hhmi.org/about/labsafe/lcss.html.

5.9 USING THE NIOSH POCKET GUIDE

5.9.a The *"NIOSH Pocket Guide to Hazardous Chemicals,"* prepared by The National Institute for Occupational Safety and Health (NIOSH), presents key information and data in abbreviated or tabular form for chemicals or substance groupings.

(1) This very useful guide includes chemical name, structure, formula, and CAS number; exposure limits; Immediately Dangerous to Life and Health (IDLH) concentrations; personal protection recommendations; physical description of the substance; chemical and physical properties; incompatibilities; first aid; and health hazards.
(2) The Pocket Guide can be viewed online or downloaded at http://www.cdc.gov/niosh/npg/npg.html.
(3) **Hard copies** are located in the Biology & Chemistry stockrooms, and in the Chemical Hygiene Office.

5.10 USING THE "RAPID GUIDES"

5.10.a *"Rapid Guide to Hazardous Chemicals in the Workplace"* 4th Edition
ISBN 0-471-35542-9

(1) This Pocket Guide is similar to the NIOSH guide in providing the relevant hazard information (PELs, TlVs, chemical & physical properties, health hazards, and a safety profile). It does not provide personal protection information.
(2) **Hard copies** are located in the Biology & Chemistry stockrooms, and in the Chemical Hygiene Office.

5.10.b *"Rapid Guide to Chemical Incompatibilities"*
ISBN 0-89573-273-4

(1) This is an extremely useful alphabetical listing of over 8,500 compounds that describes those chemical combinations that are believed to be dangerously reactive.
(2) **Hard copies** are located in the Biology & Chemistry stockrooms, and in the Chemical Hygiene Office.

5.11 SOME ADDITIONAL GUIDES

5.11.a NFPA *"Fire Protection Guide to Hazardous Materials"* 13th Edition

(1) Published by the National Fire Protection Association, the six documents that make up this guide can "be used to identify the hazardous properties of most of the chemicals in commercial use today."
(2) **Hard copies** are located in the Biology & Chemistry stockrooms, and in the Chemical Hygiene Office.

5.11.b *"Genium's Handbook of Safety, Health, and Environmental Data"*
ISBN 0-07-024577-0

(1) This three-volume set contains an alphabetical listing of over 4500 chemicals that acts as a "quick, yet comprehensive, source of information about hazardous materials."
(2) **Hard copies** are located in the Chemistry stockroom and in the Chemical Hygiene Office.

CHAPTER 6

"Engineering Controls: When & How to Use Fume Hoods and Other Protective Equipment"

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

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

29 CFR 1910.1450(e)(3)(ii)

6.0 INTRODUCTION

The primary goal of this Safety Manual is to provide policies and guidelines that, when properly followed, protect persons from harmful exposure to hazardous chemicals. This chapter contains criteria and guidelines that will be used to determine if engineering controls and/or personal protective equipment are required to minimize or eliminate exposure to hazardous substances.

6.1 QUICK GUIDE – WHEN TO WEAR GOGGLES & OTHER BASIC PPE

(See Sections 4.2 for detailed guidelines)

6.1.a Goggles & Proper Personal Clothing

Chemical splash resistant safety goggles (ANSI Z87.1-2003; Type H – indirect venting) and proper personal clothing must be worn at all times when you are:

(1) Working with hazardous chemicals,
(2) In a room where others are using hazardous chemicals, or
(3) In a room where hazardous chemicals are available for use (i.e., chemicals are on shelves or countertops and are not stored in closed cabinets), because such chemicals could be accidentally knocked over resulting in a release of the substance.
(4) Type H goggles are also rated as impact resistant, and must be worn when conducting procedures that involve vessels that are under either sufficient positive/negative pressure such that an accidental breaking of the vessel would result in flying debris.

6.1.b Proper Personal Clothing

Basic PPE includes the daily clothing that you wear. To ensure that you are wearing the proper personal clothing, follow these guidelines:

(1) Wear long pants.
(2) Wear shoes with fully closed tops and heels. Sandals, open-toed, or open-heeled footwear are not allowed.
(3) Wear shirts that do not expose considerable amounts of skin; the midsection of the body must be covered.
(4) Lab coats are strongly recommended.
(5) Do not wear clothing with excessively loose sleeves and other material
(6) Loose, long hair should be tied back
(7) Loose jewelry should be removed (it is best to not wear any jewelry in the lab).

6.1.c Gloves

(1) The appropriate gloves are necessary while handling any hazardous substance, including excessively hot or cold substances. See Section 4.2.d(3) for details.

6.1.d Benchtop Safety Shields. Note that the use of a closed fume hood sash may suffice, but realize that there may be situations when a safety shield must be used inside a fume hood. The shield must be placed between the apparatus and the worker. These shields (in addition to chemical splash-resistant goggles) must be used when:

(1) A higher-than-normal splash hazard exists (e.g., heating concentrated corrosives).
(2) The contents are under a positive or negative pressure that is sufficiently strong enough to potentially cause the container to break (refer to manufacturer's specifications).

6.2 ENGINEERING CONTROLS – REQUIREMENTS & OPERATING PROCEDURES

6.2.a General Room Ventilation of the Laboratories – Requirements

Ventilation is the process of supplying fresh air to an enclosed space in order to refresh/remove/replace the existing atmosphere; in other words, it is an engineering control. Ventilation removes contaminants such as fumes, dusts or vapors to provide a healthy and safe working environment. Ventilation is accomplished within St. Olaf laboratories by mechanical means (i.e., fans or blowers). **In accordance with the Laboratory Standard, the following Policies must be met before a laboratory can be used:**

(1) General ventilation in the St. Olaf College laboratories must be consistent with the ANSI Standard Z9.5-2003 ("Laboratory Ventilation") and be maintained within 6-10 air changes per hour.
(2) Laboratory air for each individual lab is exhausted directly to the outside and is not recirculated.
(3) Laboratory procedures must not be started if there is a possibility that the ventilation system cannot properly exhaust the gas or vapor.
(4) If any of the above policies are not being met, then the laboratory will be temporarily shut down (no experiments or activities) until the problem has been corrected.

6.2.b Fume Hoods – Operating Requirements Prior to Their Use

Laboratory hoods control exposure to toxic, offensive and flammable vapors by preventing the localized build-up of potentially hazardous concentration of these vapors. In accordance with the Laboratory Standard, the following Policies must be met before a fume hood can be used:

(1) **Workers per Hood**. There must be 2.5 lineal feet of hood space for each worker who spends the majority of his or her time performing procedures that require a fume hood.
(2) **Face Velocity**. The fume hood face velocity is maintained at 60 linear feet per minute. A calibrated alarm on each hood will sound if the flow rate falls outside this range - if this monitor is not working properly, inform the stockroom manager or CHO immediately. <u>Do not use the hood if you hear the alarm</u>.
    (a) **Face Velocity Monitor**. Each laboratory fume hoods at St. Olaf College is equipped with an Air Velocity Monitor that continuously monitors the airflow. As the exhaust fan draws air through the device, a sensitive constant temperature thermistor measures flow and lights a green (normal), yellow (high), or red (low) LED, and also gives off an audible alarm if the flow rate is either above or below the 60 lfpm acceptable range. While this device does not ensure optimal operation of the hood, it provides valuable feedback to the user.

6.2.c Fume Hoods, Other Ventilation Devices, and Room Ventilation – Who Services Them?

Facilities personnel, together with the CHO, ensure that the following services to the Fume Hoods, Snorkel Exhausts, and Room Ventilation are conducted:

(1) Annually inspect and perform required maintenance.
(2) Ensure adequate capture/containment exhaust flow of the fume hoods.
(3) Test fume hoods using the flow visualization and face velocity measurements modified from ANSI/ASHRAE 110-1995 ("Method of Testing Performance of Laboratory Fume Hoods").
(4) Maintain written records of annual inspections and all maintenance activities.
(5) Furthermore, the Department of Facilities recognizes the importance of properly functioning fume hoods to the safety and health of all St. Olaf employees and visitors, and accordingly has at least one person "on call" in case an immediate repair is needed (see Section 2.3.l).

6.3 FUME HOODS – WHEN AND HOW TO USE THEM

6.3.a Fume Hoods – When to Use Them

To ensure that the user does not exceed OSHA or ACGIH regulations, fume hoods will be used when:

(1) The TLV or PEL is below 50 ppm or 100 mg/m^3.
(2) A chemical has an NFPA rating of 3 or 4 in any category and you are handling > 250 ml or g (your supervisor may instruct you to use a hood even while working with smaller amounts).
(3) The Lethal Dose 50 (LD_{50}) is below 50 mg/kg (skin), or below 5 mg/kg (oral).
(4) The vapor pressure is above 225 mm Hg at 20° C.
(5) For all work involving "Particularly Hazardous Substances" (see Section 8.17)
(6) Whenever flammable vapors are likely to approach one tenth of the lower explosion limit (LEL).
(7) Whenever noxious odors are given off.
(8) Whenever working with a volatile substance.
(9) Whenever there is a possibility of releasing toxic vapors, dusts, or gases.
(10) Whenever the chemical has a high vapor pressure, meaning that it evaporates quickly at room temperature, it will be used in a fume hood or else respiratory protection is needed. Those controls are necessary even if the chemical with the high vapor pressure also has a very high TLV or LD_{50}, because such chemicals are likely to reach their exposure limits in air at least as quickly as a chemical with low exposure guidelines and a low vapor pressure.
(11) If an operating fume hood is not available, a respirator will be used in accordance to the St. Olaf College Respirator Protection Program.

6.3.b Fume Hoods – How to Use Them

An appropriately functioning hood requires adequate airflow and an absence of turbulence. Air moves from the lower front of the hood to the back and then out ductwork at the top of the unit. ***To ensure that the fume hood is operated properly:***

(1) Wear all appropriate PPE at all times. Keep the sashes clean so that you have a clear view inside the hood.
(2) NEVER stick your head inside a fume hood.
(3) The Hood Sashes:
    (a) Keep all sashes closed at all times except when the operator is in the actual process of manipulating objects within the hood.
    (b) The bottom of the vertical sash will, in general, be raised no higher then 18 inches while manipulating items within the hood (this level is marked on the side of each hood).
    (c) If the vertical sash is raised then the horizontal sashes MUST be closed in an overlapping manner.
    (d) If a horizontal sash is open then vertical sash MUST be lowered completely.
    (e) NEVER bend down so low that the sash no longer forms a safety barrier between your head and the items inside the fume hood.
    (f) Placing a horizontal sash in front of your body while manipulating objects within the hood is the preferred set-up. This allows the sash to act as a safety shield.
    (g) Keep the sash glass clean and do not place any unauthorized posters, decals, etc. on the hood sash or front (authorization is by the CHO only).
(4) Placement of objects inside hood:
    (a) All objects will be placed at least 6 inches behind the hood sash opening to ensure proper air containment.
    (b) Place any apparatus that can potentially emit fumes/vapors as far towards the rear of the hood as is feasible to further minimize the possibility of vapors from escaping into the room.
    (c) Do not block the exhaust slot located at the lower base of the back wall of the hood.
(5) Do not store chemicals or equipment in a hood unless it has been specifically designated as a "storage only" fume hood. Do not "clutter" the fume hood.
(6) Minimize disturbance of airflow in and around a hood:
    (a) When a person is physically performing work in a partially-opened hood, please be aware of how you walk past the hood since quick movements can disrupt the airflow in front of a hood.
    (b) Perform body and hand/arm movements in slow, deliberate movements to minimize disruption of airflow in and around the fume hood.

(7) Although all fume hoods are equipped with a primary (audible) alarm, hood users should conduct a secondary test to check for air-flow. One such common test is to hang/tape a piece of kimwipe tissue from the bottom of the hood sash. The lower free edge of the kimwipe will be drawn into the hood when the hood is operating properly. If the kimwipe is not drawn into the hood, assume that the hood is not functioning properly. Close the sash, do not use the hood, and report the problem to the Stockroom Manager and CHO.

(8) Follow any additional operating procedures that may be posted on your particular hood.

(9) **Leaving experiments in unattended hoods.** If an ongoing experiment/procedure must be left unattended during the day or overnight, the user must fill out two copies of fume hood "Experiment Activity Tag" (see Appendix C). Place one copy on the fume sash and the other copy on the laboratory door.

6.4 FUME HOODS – WHAT IF I HEAR AN ALARM OR THE HOOD DOESN'T SEEM TO BE WORKING PROPERLY?

An audible alarm warns of low airflow and requires manual resetting.

6.4.a Alarm Procedures

(1) Upon hearing an audible alarm, the observer should identify the laboratory space emitting the signal.
  (a) If the observer is not in the lab space, determine if it appears safe to enter.
  (b) If there is a question about entering a lab space, the observer should look for an "Experiment Activity Tag" on the lab door or immediately contact the stockroom manager or CHO.

(2) Identify the specific hood that is the source of the alarm.

(3) Check to see if the bottom of the hood sash is below the label that marks the maximum operating height; the label is located on either side of the sash track. If the sash is above the marks, carefully lower the sash and wait 15-20 seconds to see if the alarm shuts off.

(4) **If the alarm continues to sound:**
  (a) Press the "ACK" button on the indicator to acknowledge the alarm.
  (b) *Record the room number, hood location and exhaust hood number.* The hood number is generally found on the upper left switch panel and contains three letters followed by two numbers [EXH-##].

(5) Look for a Experiment Activity Tag. The tag contains information about the current use of the hood and contact information for the faculty/staff supervisor and experimenter.
  (a) *If there is no tag present then proceed to step 7a or 7b.*

(6) Examine the right-hand side of the Experiment Activity Tag ("*If alarm continues to sound, does this hood need immediate repair?*").
  (a) *If "NO" is circled, then proceed to step 7a or 7b.*
  (b) *If "YES" is circled, then emergency repair is needed. Proceed to step 7c.*

(7) Report a hood alarm according to the appropriate step listed below.

(7)(a)	(7)(b)	(7)(c)
Non-emergency Repairs		**Emergency Repair Only**
8:00 a.m. – 4:30 p.m.	**After Hours Reporting**	**24 Hours/Day**
Inform the stockroom manager about the alarm. If the stockroom manager is not available, contact the CHO, lab supervisor, or Depart. chair.	Email and/or send a phone message to the stockroom manager and the chemical hygiene officer.	Contact experimenter and lab supervisor to inform them of the hood alarm.
Provide room number and exhaust hood number.	Inform them of the alarm, its location, exhaust hood number and current time.	Contact St. Olaf Facilities (3281) to initiate suitable repair protocol. If no answer at Facilities, call Public Safety (3666).
The stockroom manager will contact Facilities to set up a repair schedule, and will tape an "Out of Service" sign to the sash window of the hood.	Make note of alarm discovery on the Hood Activity Tag or tape an "Out of Service" sign to the sash window of the hood.	Call stockroom manager and the chemical hygiene officer and inform them of the alarm.
	The chemical hygiene officer and stockroom manager will check alarm during the next business day.	

"Out-of-Service" Tags are located on the right side of the Chemistry & Biology stockroom fume hoods.

Contact Information:

Chemistry Stockroom Manager:	Jodi Schmelz	3401	schmelz@stolaf.edu
Biology Stockroom Manager:	Johanna Tran	3393	tran2@stolaf.edu
Chemical Hygiene Officer:	Pat Ceas	3560	ceas@stolaf.edu
After hours emergency repair:			
	St. Olaf Facilities	3281	
	St. Olaf Public Safety - 24 hr phone 3666		
	Pat Ceas	507-321-0379	

6.5 GLOVE BOXES – WHEN AND HOW TO USE THEM

CHAPTER 7

"Basic Rules and Procedures

for

Working with Hazardous Chemicals"

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

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)(3)(i)

"The following [rules] should be used for essentially all laboratory work with chemicals"

29 CFR 1910.1450 Appendix A, Section E.1.

7.0 INTRODUCTION

Before working in the laboratory, all laboratory workers must read and follow these general safety rules and procedures so that the laboratory workers will understand the risks associated with the health and physical hazards that are present in the laboratory.

NOTE: These rules and procedures are designed to protect laboratory workers from exposure to hazardous situations. Certain rules may not apply at all times (e.g., there is no need to wear goggles in a room that does not contain hazardous chemicals, objects, or situations, but the 'Rules for Housekeeping,' etc. must still be followed). Consult the Chemical Hygiene Officer (CHO) if you have questions regarding the following safety rules and procedures.

7.1 FUNDAMENTAL PRINCIPLES & RULES

7.1.a ***Awareness is the most fundamental principle of chemical safety*:**

(1) The hypothetical question ***"What would happen if…?"*** should always be posed before an experiment or procedure is attempted. Do not conduct the procedure unless you can answer all "*What if*" questions.
(2) Never underestimate the risk and hazards involved in working with chemicals.
(3) Plan ahead. Review thoroughly all proposed laboratory procedures to determine the potential health and safety hazards before you begin work.
(4) Assume that substances of unknown toxicity are hazardous.
(5) Assume that a mixture will be more toxic than its most toxic component.
(6) Be alert to unsafe conditions and ensure that they are corrected as soon as they are detected.
(7) Be prepared for accidents or unexpected events.
  (a) Before beginning an experiment, know what specific action to take in the event of an accidental release of a hazardous substance.
  (b) Always know the location of safety equipment in your area, and the emergency safety procedures and contact numbers for your area.
  (c) If a test result is different than the predicted, a review of how the new result impacts safety practices must be made.

7.1.b Fundamental steps that must be followed before working with chemicals:

(1) **Identify** the **chemicals** to be used.
(2) Make sure that all **containers** are **properly labeled** (see Section 7.3.a).
(3) **Hazard Identification** (see Chapter 5).
  (a) Consult the label, MSDS, and other sources for information to evaluate the hazardous properties of a chemical, including routes of exposure and exposure limits (see Sections 5.3-11).
  (b) Determine if a less hazardous (or nonhazardous) chemical can be substituted.
(4) **Characteristics of the Chemical**. Laboratory workers must know the following:
  (a) Physical properties of the chemical (e.g., aerosol, liquid, low vapor pressure that can lead to fast evaporation and increase exposure)
  (b) Type(s) of hazard (corrosive, flammable, toxic, etc.)
  (c) Chemical incompatibilities (e.g., mixing of certain chemicals can cause fires, release of toxic fumes, etc.)
  (d) Route(s) of exposure (inhalation, absorption through skin, ingestion, injection)
  (g) The amount of exposure that is considered to be safe
  (h) The lethal dose of any toxic chemical
  (i) How the chemical acts on the body (acute or chronic; carcinogen; mutagen; teratogen)
  (j) Symptoms and target organs of over-exposure
(5) Identify the **Circumstances of Use**.
  (a) Calculate the amounts to be used or the possibility of generating new or unknown substances.
  (b) Plan the positioning of equipment before beginning any new operation.
  (c) Review thoroughly all proposed laboratory procedures to determine the potential health and safety hazards before you begin work.
  (d) Is it possible for new or unknown substances to be generated?
  (e) Are any chemicals known to cause birth defects, etc.?
  (f) Do any workers have known sensitivities to specific chemicals?

(6) **Standard Operating Procedures**. For any chemical that is defined as hazardous, the SOPs for working with that type of hazard (Chapter 8) must be followed in addition to the safety rules outlined in this chapter.

(7) **Follow all safeguards** for using the chemicals including:
   (a) When and how to use control measures (fume hoods, etc.) (see Chapter 6).
   (b) Appropriate personal protective clothing and equipment (see Sections 4.2.c-d).
   (c) How and where to properly place the chemical when in use (see Sections 7.6.a).
      (Remember: The chemical is actually used for only minutes in the average workday, the rest of the time it is being "kept" on the laboratory bench or in the fume hood)
   (d) How and where to properly store the chemical when <u>not</u> in use (see Section 7.6).
   (e) The proper methods of handling & moving chemicals (see Section 7.5).
   (f) The proper procedures for handling chemical wastes (see Chapter 10).
   (g) Regularly inspect laboratory equipment. Do not use if the item is even suspected to be defective.

(8) **Prior Approval.** Obtain approval for using the chemicals listed in Section 7.1.i(1) *before* using them.

(9) **Using Substances with an NFPA Hazard Designation of '4' or 'S'**. Faculty/Staff who intend to use these chemicals must inform the CHO and Department Chair at the time the order is placed regarding its intended use, standard operating procedures, storage, etc.

(10) **Particularly Hazardous Substances.** OSHA recognizes certain groups of chemicals as being "particularly hazardous" and requires that specific provisions be followed. These substances include (a) 'select carcinogens', (b) reproductive toxins, and (c) substances that have a high degree of acute toxicity. See Section 8.17 for more information.

7.1.c Minimize all chemical exposures (see Section 4.2):

(1) The Permissible Exposure Limits (PELs) of OSHA and the Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists must not be exceeded.
   (a) Ensure that adequate room ventilation is in place.
   (b) Use fume hoods or other ventilation devices as required (See Chapter 6).

(2) **Food, tobacco, cosmetics:**
   (a) Never eat, drink, chew gum, smoke, or apply cosmetics in laboratories or chemical storage areas.
   (b) Food, beverage, or tobacco products are not allowed in laboratories or chemical storage areas. Food, drink, and especially tobacco absorb chemical vapors, particulates, and gases from the air.

(1) **Personal Protective Equipment Policy:**
   (a) Skin and eye contact with chemicals should be avoided as a fundamental rule.
   (b) The following PPE must be used as required in Sections 4.2.c & 4.2.d:
      (i) Chemical splash goggles & any other required face protection.
      (ii) Protection of skin from chemical splashes (including appropriate clothing, shoes, and gloves).
   (c) Chemical splash goggles must be provided to all laboratory visitors. Visitors must also wear all appropriate PPE, as required in Section 4.2.d.

7.1.d <u>NEVER</u> <u>work</u> <u>alone</u> in a laboratory <u>if</u> <u>the</u> <u>procedure</u> being conducted <u>involves</u> <u>hazardous</u> <u>substances</u>. If the procedure is deemed to not be hazardous then someone must still know of the solitary worker and check on him/her at regular intervals.

(1) **Alone** means a person is beyond the visual or auditory range of any other individual for more than a few minutes at a time (definition from the National Safety Council).

(2) Undergraduate researchers may work in the building after normal daytime hours only when **all** of the following conditions are satisfied:
   (a) Permission of the lab supervisor is given to work at a specific time on a specific activity; **and**
   (b) The specific activity is an approved standard operating procedure of the research group or course; **and**
   (c) The researcher adheres to all safety policies and procedures; **and**
   (d) The researcher is accompanied by another person (co-worker, colleague, etc.); **and**
   (e) The space in which the work is to be done has two or more points of egress; **and**
   (f) The individual is enrolled in a course requiring this work, or is a research employee, or is a departmental work-study awardee whose job description includes this work.

7.1.e Pets are not allowed inside campus buildings. This rule follows College policy.

7.1.f Minors are not allowed in laboratories where hazardous chemicals are used or stored, unless they are participating in a departmentally recognized outreach program.

7.1.g Deposit chemical wastes in appropriately labeled receptacles and follow all protocols, including proper labeling, for the disposal of waste chemicals (Chapter 13).

7.1.h Any "horseplay" or behavior that is harassing, disruptive, aggressive, or in any way presents a hazard to those working in the laboratory is forbidden. Any person or groups of persons engaging in such behavior will be required to leave the laboratory.

7.1.i Approvals

(1) **Prior Approval** to proceed with a laboratory task **must be obtained** from the CHO **before**:

(a) Using the following substances (this list is adopted from the University of Minnesota's CHP):

- Arsine
- Boron trifluoride (gaseous)
- Carbon monoxide
- Carbonyl fluoride
- Chlorine pentafluoride
- Chlorine trifluoride
- Diborane
- Dinitrogen tetroxide / nitrogen dioxide
- Fluorine
- Germane
- Hexafloro butyne
- Hydrogen cyanide
- Hydrogen fluoride (anhydrous)
- Hydrogen selenide
- Hydrogen sulfide
- Oxygen difluoride
- Perchloric Acid
- Phosgene (gaseous)
- Phosphine
- Phosphorous pentafluoride
- Picric Acid
- Selenium hexafluoride
- Silane
- Silicon tetrafluoride
- Stibine
- Sulfur dioxide
- Sulfur tetrafluoride
- Tellurium hexafluoride

(b) Using **substances that have a High Degree of Acute Toxicity.** Compounds with a high degree of acute toxicity are those that have a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rates weighing between 200 and 300 grams each.

(i) Refer to Table 18 (Appendix A) for a list of several examples of highly acute toxic materials.

(ii) Table 19 (Appendix A) lists the Category 1 Gaseous Inhalation Hazards as listed by the DOT.

(iii) Table 20 (Appendix A) contains a list of toxicity ratings/lethal doses based on ingestion amounts.

(iv) Refer to Section 8.17.b for SOPs for working with substances that have a high degree of acute toxicity.

(2) **Approval to Continue** with a laboratory task that requires 'Prior Approval' (see Section 7.1.i(1)) should be obtained from the CHO in the following circumstances:

(a) There is a failure of the required safety equipment pertinent to the process, especially safeguards such as fume hoods or vacuum apparatus.

(b) There are unexpected byproducts that result in the creation of unknowns or unplanned hazardous wastes.

(c) When an increase in the scale of an experiment is planned.

(d) If individuals suspect exposure, become ill due to suspicious circumstances related to working in a laboratory, or otherwise suspect a failure of engineered safeguards, an 'Approval to Continue' must be received even if 'Prior Approval' was not required.

(3) **Request for Approval.** For laboratory tasks that require 'Prior Approval' a 'Request for Approval' must be submitted by the laboratory supervisor to the CHO at least two weeks prior to the intended use.

(a) A request must be submitted prior to the <u>first</u> time the substance is purchased or otherwise acquired.

(b) For a course/research that occurs on an intermittent but regular basis (e.g., a course that is taught every Fall Semester), the laboratory supervisor does not need to submit a new Request for Approval at the beginning of each school year provided that the standard operating procedures (see 7.1.i(e)) have not changed.

(c) The substance must not be loaned or given to another research group without prior approval.

(d) For existing inventory, a request must be submitted prior to the first use of the substance.

(e) A "Request for Approval" must include:
  (i) The identity and quantity of the substance to be used.
  (ii) The intended purpose. Who will be handling the substance? What is the location where the substance will be handled? When will the substance be used (e.g., once per semester; every week)?
  (iii) The possible hazards in the handling or storage of the substance.
  (iv) The safety precautions to be taken.
  (v) The existing protective equipment and engineering controls.
  (vi) Provisions for emergency handling of overexposure, spills, and wastes.

(f) After a "Request for Approval" is received, the College Chemical Health & Safety Committee will consult with appropriately qualified individuals (inside or outside of St. Olaf). Recommendations concerning approval decisions will be sent to the appropriate departmental chair.

(4) Records of prior approval decisions will be maintained by the Chair of the Departmental Safety Committee and by the Chemical Hygiene Officer.

7.1.j Unattended Operations – If an experiment must be left unattended, the following rules must be followed:

(1) Obtain permission from the lab supervisor prior to conducting any unattended operations.
(2) Leave the lights on, and post an appropriate warning note.
(3) Make sure that water hoses are securely fastened to faucets and apparatus to avoid floods.
(4) Return periodically to check on the unattended operation (frequency determined by the Laboratory Supervisor).
(5) Provide for the containment of toxic substances in the event of equipment or utility failure.
(6) **If using a fume hood**, you must fill out and post the "**Experiment Activity Tag**" (Section 6.4) sign to inform others (e.g., Facilities) that an unattended operation is in progress.

7.1.k Environmental Monitoring – Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when:

(1) Testing or redesigning hoods or other ventilation devices, or
(1) Where a highly toxic substance is stored or is used three times a week or more.

7.1.l Emergency Response (See Chapter 12 for details)

(1) The laboratory worker must have knowledge of and be continually aware of:
  (a) The location and the proper use of emergency equipment such as eye wash stations, safety showers, and fire extinguishers.
  (b) The location of telephones and emergency telephone numbers.
  (c) The posted emergency plans, including whom to call for a particular incident, evacuation procedures, and chemical spill cleanup procedures (stockroom managers & CHO will take charge of large spills).

(2) **Phone Tree.** Departmental Chairs and Laboratory Supervisors must make an emergency alert phone tree to ensure that all relevant personnel are informed of an accident. The tree must require that the person who initiates the calls begin with a call to 9-911 followed by a second call to Campus Public Safety (3666).

7.2 BASIC RULES & PROCEDURES – USING ADDITIONAL SOURCES OF SAFETY INFORMATION

There are a variety of additional sources that should be consulted for additional information on working with chemical substances. The following items, although not comprehensive in scope, are meant to serve as additional sources of information for working with hazardous chemicals.

7.2.a ***"Prudent Practices in the Laboratory: Handling and Disposal of Chemicals"***
ISBN 0-0309-05229-7

(1) Published by the National Research Council. This book is an excellent reference on laboratory safety for science researchers, educators, stockroom managers, and students. It addresses such topics as chemical procurement, handling, storage, and waste disposal; risk assessment; proper personal protective equipment; and general safety guidelines.
(2) **Contains Laboratory Chemical Safety Summaries:** These safety summaries are "specifically tailored" to the needs of the laboratory worker and provide information on chemicals in the context of laboratory use. Eighty-eight LCSSs are included in *Prudent Practices*.
(3) "*Prudent Practices*" can be viewed online at http://www.nap.edu/books/0309052297/html/
(4) **Hard copies** are located in the Biology & Chemistry stockrooms, and in the Chemical Hygiene Office.

7.2.b ***Safety in Academic Chemistry Laboratories* (7th Edition)**
Vol. 1: Accident Prevention for College and University Students ISBN 0-8412-3863-4
Vol. 2: Accident Prevention for Faculty and Administrators ISBN 0-8412-3864-2

(1) Written by the American Chemical Society Joint Board-Council Committee on Chemical Safety. These booklets are an excellent short reference on laboratory safety for science researchers, educators, stockroom managers, and students.
(2) Vol. 1 can be viewed online at http://membership.acs.org/c/ccs/pub_3.htm.
(3) Vol. 2 can be viewed online at http://membership.acs.org/c/ccs/pubs/SACL_faculty.htm
(4) **Hard copies** of these booklets are provided free to all St. Olaf laboratory workers.

7.2.c **"2000 Emergency Response Book"** U.S. Govt, Printing Office

(1) Developed jointly by the United States, Canada, and Mexico, this guidebook is meant to allow first responders to quickly identify the specific or generic hazards of a material. For the laboratory worker it provides a quick summary of the hazards of a substance, and the proper protective clothing and evacuation procedures in case of a large spill.
(2) **Hard copies** are located in the Biology & Chemistry stockrooms, and in the Chemical Hygiene Office.

7.2.d **"*Hazardous Laboratory Chemicals Disposal Guide*"** ISBN 1-56670-108-2

(1) This useful Guide is intended to help the laboratory worker properly dispose of small quantities of waste, spilled, or surplus chemicals. It also contains the physical & chemical properties, as well as the physiological and health hazards, of over 500 commonly used chemicals.
(2) **Hard copies** are located in the Chemistry stockroom and in the Chemical Hygiene Office.

7.2.e **"Biosafety in the Laboratory"** ISBN 0-309-03975-4 and **"Biosafety in Microbiological and Biomedical Laboratories"** CDC 93-8395

(1) These books provide recommendations for the handling and disposal of microbial and/or infectious substances.
(2) **Hard copies** are located Biology Stockroom Office, Holland 206, and in the Chemical Hygiene Office.

7.2.f **The following references are found in St. Olaf Chemical Hygiene Office**

(1) "*Handbook of Chemical Health and Safety*".
(2) "*Handbook of Laboratory Health and Safety*"
(3) "*CRC Handbook of Laboratory Safety*"

7.3 CHEMICAL & HAZARD IDENTIFICATION (SIGNS & LABELS)

7.3.a Proper Labeling of Containers:

(1) Every container that holds a chemical must be labeled properly. All newly delivered substances entering the facilities must contain accurate labeling from the manufacturer. No substance is considered to be delivered properly unless an MSDS sheet has also been received (or is on file).

(2) **Labels** must be **clearly legible** and free of encrustation or contamination.

(3) **Labels** must be **firmly attached** to containers.

(4) **All Containers Except "Immediate Use" Containers Must Have the Following Information:**

- (a) The name of the substance. The label on the original container must not be removed or defaced.
- (b) Chemical Abstract Service (CAS) Registration Number (if available).
- (c) The appropriate NFPA hazard codes.
- (d) Target organ effects (if appropriate).
- (e) Any other relevant warnings (e.g., "Corrosive," "Poison," "Oxidizer").
- (f) If any of the above information is not on the label, then appropriate stickers/labels must be added to the container. See the Stockroom Manager for the appropriate stickers.
- (g) **Dates.** Once a substance has been accepted into the facility, three dates must be clearly legible (hand-written or typed) on the outside of each original container:
  - (i) Date Received. This date must be added by the researcher.
  - (ii) Date Opened. This is the date that the container is first opened. This date must be added by the researcher.
  - (iii) Determination Date. The date at which time the supervisor must examine the container's contents to see if it is safe to keep. This date must be added by the researcher.

(5) **Squeeze-Bottles**. These bottles MUST be labeled with the name of the substance, NFPA codes, target organ effects, and other relevant warnings (e.g., "Corrosive," "Poison," "Oxidizer").

(6) "**Immediate Use" Containers**. According to Minnesota Rules 5206.0100 Subpart 10, an immediate use container is "a container into which substances are transferred from labeled containers and which will be under the control of and used only by the person who transfers it from a labeled container and only within the work shift in which it is transferred. This applies to containers such as test tubes, beakers, graduates, vials, pitchers, pails, or similar containers which are routinely used and reused."

(7) **Substances Developed in the Laboratory.**

- (a) All substances generated on-site must have a label listing all essential information, as outlined in Section 7.3.a, and include the name of the person responsible for the substance.
- (b) If the composition of the chemical is known, the laboratory supervisor shall determine if it is a hazardous substance. If the substance is hazardous, then the laboratory supervisor will ensure that the involved laboratory workers have the proper training and knowledge to handle the substance.
- (c) If the composition of the substance is unknown, the laboratory supervisor shall assume that it is hazardous and instruct the laboratory workers in the appropriate handling methods.

7.3.b Safety & Identification Signs – Obey These Signs

(1) "No Food or Drink Allowed" and "Safety Goggles Required" signs have been placed at the entrances of all laboratories.

(2) OSHA-compliant identification signs are located throughout each laboratory and identify the locations of all fire extinguishers, safety showers, eyewash stations, first aid kits, and spill kits.

(3) Inspection tags must be located on all safety showers, eye wash stations, and fire extinguishers.

(4) Identification signs also allow personal to quickly locate the MSDS binder and sharps containers that are found in the labs.

(5) OSHA-compliant safety and identification signs have been placed at the entrance to the stockrooms ("Authorized Personnel Only"), and the entrance to the ground floor Chemical Storage Facility.

(6) Yellow and black-striped caution tape has been placed on the floor underneath every safety shower to remind workers that they must not block access to the safety showers.

(7) Warning or instructional signs have been placed in areas or on equipment where special or unusual hazards exist.

(8) Each laboratory has a list of emergency telephone numbers (Posted on a hall entrance) of emergency personnel/facilities, supervisors.

(9) Each laboratory shall have an NFPA diamond, located on the hallway entrance of each door, that indicates the types and levels of hazards present in the room.

(10) Designated Areas or areas where other special hazards exist (e.g., Satellite Accumulation Points) are clearly labeled and isolated, and are to be used for only the designated purpose.
(11) Emergency exits are clearly marked.

7.4 CHEMICAL PROCUREMENT

7.4.a Procurement, Container Type, and Amounts:

(1) **Knowledge of Items.** Before a substance is ordered information on proper handling, storage, and disposal, as well as the substance's hazardous characteristics, must be known to those who will order, receive, and/or work with the substance.
(2) **Plastic Coating on Jars.** Attempt to purchase all chemicals in containers with a protective plastic coating that will keep the container from shattering if dropped. A special effort must be made to purchase all corrosives in containers that have a protective plastic coating.
(3) **Minimize Purchases.** In general, purchase no more than the amount that can be used in a 9-12 month period. Do not "stockpile" chemicals for possible future use.

7.4.b Substituting for Less Hazardous Chemicals:

(1) Whenever possible, substitute less hazardous chemicals. Examples include toluene for benzene, dichloromethane for chloroform and carbon tetrachloride, and methyl tertiary-butyl ether (MTBE) for ethyl ether.

7.5 HANDLING, MOVING, & TRANSPORTING CHEMICALS

Refer to Chapter 8 for SOPs on handling specific categories of hazardous chemicals, and Chapter 4 on how to avoid/minimize exposures to chemicals.

7.5.a Handling Chemicals:

(1) Unused chemicals must never be returned to stock bottles.
(2) Wear all of the appropriate PPE when working with hazardous materials
(3) Use slow, deliberate movements when working with chemicals.
(4) Stay steady on your feet; do not lean or stretch/reach excessively to grasp a jar.
(5) Never bend down or hold chemicals in such a way as to have them at face level.
(6) Hold reagent bottles and other vessels containing liquids so that any drips will be opposite the label; promptly clean off any drips.
(7) When mixing acids with water always add the acid to water; never add water to acids.
(8) Keep containers away from the edge of counters or shelves.
(9) Use secondary containment trays.
(10) Amounts on Laboratory Work Benches.
    (a) Only jars/containers with small amounts (< 2.5 l) should be kept at work stations.
    (b) Larger jars should be returned to the storage cabinets immediately after dispensing the necessary amounts

7.5.b Moving Chemicals:

(1) **<u>Never</u> <u>hand-carry</u> an exposed jar <u>through</u> <u>a</u> <u>public</u> <u>corridor</u>.**
    (a) If the container is to be hand-carried, it must be placed inside a rubber/polyethylene hand bucket. Carry the bucket with one hand and keep the other hand free.
    (b) When moving larger numbers of chemical containers or heavy containers, the containers must be placed in secondary containment trays and wheeled down a hallway on an appropriate chemical-transport cart.
(2) All necessary PPE must be worn while moving chemicals.
(3) Avoid moving chemicals through hallways during periods of heavy traffic (e.g., just after a class period has ended).
(4) When using the elevator, do not allow other passengers.
(5) Make sure that the cylinder is chained securely to the cylinder cart before moving.

7.5.c Transporting Chemicals:

(1) All appropriate Department of Transportation rules (packaging, labeling, manifests) must be followed for any hazardous chemicals that are transported to/from Campus by College personnel.
(2) Prior to the planned field event, faculty should ensure that, in the event of an accident involving chemicals in their personal vehicles, they will be covered under their personal insurance policies. Many insurance policies forbid the transport of any chemicals from the workplace in personal vehicles.
(3) When transporting chemicals to perform a "Chemistry Magic Show" or similar event, follow the ACS National Chemistry Week and Community Activities Safety Guidelines, which can be found at http://www.chemistry.org

7.6 STORAGE OF CHEMICALS

7.6.a General Rules:

(1) **Amounts Kept in Laboratories**.
   (a) The number and amounts of chemicals that are stored in the FNSM buildings should be kept to a minimum.
   (b) The amounts stored in laboratories should be maintained at an amount sufficient for only a few week's or perhaps a semester's worth of activities. All other chemicals should be kept in the SC ground floor chemical storage facility.
   (c) Only jars/containers with small amounts (< 2.5 l) should be kept at workstations, and these must be kept in secondary containment trays.
   (d) Larger jars should be returned to the storage cabinets immediately after dispensing the necessary amounts
(2) **Storing by Hazard Class**. Chemicals must be stored by their appropriate hazard class. See Sections 7.6.c-i for further details.
(3) **Secondary Containment Trays:**
   (a) All hazardous liquid chemicals must be stored in secondary containment trays if stored on open shelves.
   (b) Secondary containment trays (or buckets) must be used while moving liquids through public hallways.
   (c) Dry chemicals must be stored in secondary containment trays, or the shelves must contain some type of lip or other structure that will prevent the containers from being accidentally knocked off the shelf.
   (d) If incompatible chemicals are stored on the same shelf, then the chemicals <u>must</u> be placed in separate secondary containment trays. See section 7.6.c for further details.
(4) Chemicals must be stored in containers with lids that close tightly, form an airtight seal, yet are relatively easy to open.
(5) Chemicals cannot be stored or kept in offices or other non-laboratory settings.
(6) Read the MSDS and heed the precautions regarding the storage requirements.
(7) All chemicals are to be placed in proper storage areas by the end of each workday.
(8) Do not expose chemicals to direct sunlight or heat.
(9) Chemicals are to be stored only on designated shelves & cabinets in laboratories, stockrooms, and the Chemical Storage Facility located in the loading dock area of RNS.
(10) Chemicals are <u>not</u> to be stored in aisles, stairwells, on desks or workbenches, on floors or in hallways, or left on shelves over the workbenches that are not designated for storage.
(11) Chemicals can be stored in a fume hood <u>only</u> if the hood is clearly marked "For Chemical Storage Only-No Experimental Work" and it is not used for any other purpose.
(12) Containers must not be stacked (exceptions are the specially designed waste carboys in the Hazardous Waste Room).
(13) Liquid chemicals shall be stored below five feet in height.
(14) If solid/powder chemicals are stored above eye level, a stepladder or stool must always be used to remove/replace these containers on the shelves.
(15) Shelving units and storage cabinets must not be crowded, and individual jars must be easily reached.
(16) Storage containers shall be inspected periodically for rust, corrosion, or leakage.
(17) Damaged containers must be removed or repaired immediately.
(18) Eye-dropper bottles must not used for storing corrosive or water reactive chemicals.
(19) Dispensing tubes on carboys must be free of corrosion or aging.

(20) Chemical inventories will be performed on an annual basis, or as requested by the Chemical Hygiene Officer.

7.6.b Chemical Storage Areas:

Chemicals are stored in designated areas only. Examples in the RNS include the central Chemical Storage Facility located on the ground floor, the Stockrooms, and in designated cabinets and shelving units of various research and teaching laboratories.

(1) Cleanliness and order shall be maintained in the storage areas at all times.
(2) Storage areas (or laboratories containing storage shelves) shall be locked whenever not in use and are available only to authorized personnel.
(3) Hall doors must be kept closed at all times to ensure proper negative pressure airflow through the rooms.
(4) Open flames, smoking, and localized heating units are not permitted in chemical storage areas.
(5) Mixing or transfer of chemicals is not allowed in the central Chemical Storage Facility.
(6) Aisles, stairways and hallways in and around the storage areas shall be free from obstruction.
(7) Ladders with handrails are available where needed.
(8) **Open Storage Shelves**:
   (a) Shelves must be level and stable. Shelving units must be securely fastened to the wall or floor.
   (b) The weight limit of the shelves must not be exceeded.
   (c) Large bottles and containers (≤ 5 gallons) shall be stored on shelves no higher than two feet from the floor.
   (d) All liquid chemicals must be stored in secondary containment trays.
   (e) Dry chemicals must be stored in secondary containment trays, or the shelves must contain some type of lip or other structure that will prevent the containers from being accidently knocked off the shelf.

7.6.c Store by Hazard & Compatibility Classes:

(1) The primary method of segregating & storing chemicals is NOT by alphabetic order.
(2) **Chemicals must be stored by Hazard Class** (e.g., flammables with flammables, oxidizers with oxidizers). See Sections 7.6.d-i for further information on storing by hazard class.
(3) Within hazard classes, **chemicals must be stored according to compatibility** (e.g., Inorganic Acids Acid must not be stored next to Organic Acids, unless separated by secondary containment trays).
(2) If a chemical exhibits more than one class of hazard, then you must choose a hierarchical method to segregate these chemicals (e.g., chemicals that are both corrosive and flammable should be stored in their own cabinet, separated from all other chemicals).
(5) **Incompatible chemicals must be physically segregated** (i.e., if two jars of incompatible chemicals break simultaneously, the chemicals must have been stored in such a way so that the spilled chemicals can not come in contact with each other).
   (a) The best method is to store incompatible chemicals in separate secondary containment trays and on separate shelves so that a chemical cannot spill on top of an incompatible chemical.
   (b) A **Chemical Compatibility Guide** can be found in Table 9 (Appendix A).

7.6.d Storing Flammables (See Appendix A Table 3 for a list of common flammables):

(1) Flammable liquids are stored in accordance with NFPA Standard No. 45 ("*Standard on Fire Protection for Laboratories Using Chemicals, 2000 Edition*"), and 29 CFR 1910.106 ("*Flammable and Combustible Liquids*").
(2) Within laboratories, storage of flammable liquids (including wastes) outside of approved flammable storage cabinets or safety cans (i.e., open shelves) must not exceed 10 gallons per 100 square feet of laboratory space. For the maximum amounts allowed in a laboratory see Table 4 (Appendix A).
(3) Stockroom personnel must be aware of the hazards associated with flammable materials.
(4) Flammables must be kept away from any source of ignition, flames, heat, or sparks.
(5) Refrigerators that hold flammables must be certified laboratory-grade and explosion-proof.
(6) If incompatible chemicals are stored on the same shelf, then the chemicals <u>must</u> be placed in separate secondary containment trays.
(7) Bonding and grounding wires will be used where flammables are stored and dispensed.
(8) All electrical service equipment must be explosion-proof for the appropriate class and group of flammable liquids.

(9) Absorbents are readily available in the event of leaks or spills.

(10) **Flammable Storage Cabinets:**

(a) OSHA/NFPA-compliant safety cabinets are used for the storage of flammable liquids and are designed to contain a fire for 10 minutes (i.e., enough time for a person to escape).

(b) Two vents are provided on opposite sides of the cabinet and are equipped with flame-arrestor screens. Unless externally vented, bung plugs must remain in place.

(c) Store chemicals of similar vapor density together when using mechanical ventilation (e.g., heavier-than-air vapors are vented through the bottom vent and lighter-than-air vapors through the top vent).

(d) Do not store paper or cardboard inside cabinets with the chemicals.

(e) Do not overload the cabinet shelves.

(f) These cabinets should not be located near electrical panels, or sources of heat or ignition. If a cabinet is placed near an exit, there must be a secondary means of egress from the laboratory.

(11) **Flammable Safety Cans:**

(a) Larger quantities of flammable liquids (≥ 5 gallons) must be stored in OSHA/NFPA-compliant safety cans. These cans are approved by Underwriter Laboratory (UL) or Factory Mutual (FM) for flammable and combustible (non-corrosive) liquids. They are made of 22-gauge steel, and have a self-closing lid or quarter-turn spigot.

(b) The can must be kept closed except when adding or removing liquid.

(c) The flame arrestor screen must be kept in place at all times and replaced if punctured or damaged.

(d) As with all chemicals, chemicals in safety cans must be stored in storage areas and not in laboratory work areas or hallways.

7.6.e Storing Corrosives (See Appendix A Table 14 for a list of common corrosives):

Incompatible corrosives must be physically segregated (i.e., if two jars of incompatible chemicals break simultaneously, the chemicals must have been stored in such a way so that the spilled chemicals cannot come in contact with each other). The best method is to store incompatible chemicals in separate secondary containment trays and on separate shelves so that a chemical cannot spill on top of an incompatible chemical.

(1) Always physically segregate acids from bases – use 2° containment trays if jars are on the same shelf.

(2) Always physically segregate inorganic acids from organic acids (some inorganic acids, such as Nitric Acid, are oxidizers and will react with organic acids).

(a) Always store Nitric Acid separately.

(b) Some examples of other inorganic acids are Hydrochloric Acid, Hydrofluoric Acid, Phosphoric Acid, and Sulphuric Acid.

(c) Some examples of Organic Acids are Acetic Acid, Butyric Acid, Formic Acid, Picric Acid, and Acrylic Acid.

(3) Perchloric Acid and Picric Acid require special handling and **Prior Approval** before even purchasing.

(4) Segregate oxidizing acids from flammable and combustible materials.

(5) Segregate acids from chemicals that can generate toxic gases on contact, such as sodium cyanide and iron sulfide.

(5) Segregate acids from active metals such as sodium, magnesium, and potassium.

(6) Segregate acids from solvents such as toluene and xylene.

(8) Large bottles (≥ 4 liters)of acids must be stored in acid cabinets.

(9) Absorbents or neutralizers must be readily available for acid spills.

7.6.f Storing Peroxide-Forming Chemicals (See Appendix A Table 8 for a list of common peroxide-formers):

(1) Peroxide-forming chemicals must be stored in airtight containers in a dark, cool, and dry place.

(2) Store in a flammables cabinet, away from light, heat, sources of ignition, oxidizers, and oxidizing acids.

(3) **Testing for Peroxides**. Peroxide-forming chemicals must be tested for the formation of peroxides by using the test strips that are kept in the Chemistry and Biology stockrooms.

(a) Chemicals stored in the stockrooms and Chemical Storage facility will be tested by the stockroom managers. Chemicals stored in research laboratories will be tested by the appropriate Laboratory Supervisor.

(b) For bottles with inhibiting agents added by the manufacturer:

(i) Once a bottle is opened, it must be tested monthly for peroxides.

(c) For bottles without inhibiting agents added by the manufacturer:
  (i) Once a bottle is opened, it must be tested every two weeks for peroxides.
(d) Any jar found to have peroxide formation will have Hydroquinone or Butylated Hydroxy Toluene (BHT) added to the bottle (these are stabilizing agents), and monthly testing will continue.
(e) The following concentration guidelines apply:
  (i) If peroxide levels are < 50 ppm, then the solution is still ok to use.
  (ii) If peroxide levels are ≥ 50 ppm, then the solution will be stabilized and processed for disposal.
  (iii) Do not use the substance if there is any signs of crystal formation inside the jar; immediately inform the stockroom manager & CHO and do not move the jar.

7.6.g Storing Water-Reactive Chemicals (See Appendix A Table 12 for a list of common water-reactives):

(1) Water-reactive chemicals are stored in airtight containers in a dark, cool, and dry place.
(2) A Class D fire extinguisher must be available whenever a water-reactive chemical is used. The Class D fire extinguisher is kept in the Chemistry Stockroom Office.

7.6.h Storing Oxidizers (See Appendix A Table 2 for a list of common oxidizers):

(1) Oxidizers must be stored away from flammable, combustible, and reducing agents.

7.6.i Storing Toxic Compounds:

(1) Toxic compounds are stored according to the nature of the chemical, with appropriate security employed where necessary.
(2) Toxic chemicals must be segregated in a well-identified area with adequate local ventilation.
(3) Highly toxic chemicals or toxic chemicals whose containers have been opened should be placed in unbreakable secondary containers and stored in a secure, limited-access area.
(4) The Poison Control Network telephone number (9-1-800-764-7661) must be posted.

7.7 WORKING WITH PARTICULARLY HAZARDOUS SUBSTANCES

OSHA recognizes certain groups of chemicals as being "particularly hazardous" and requires that specific provisions be followed. These substances include Select Carcinogens, Reproductive Toxins, and Substances that have a High Degree of Acute Toxicity. The Lab Standard provides more specific guidelines for the use of (1) Allergens and Embryotoxins, (2) Chemicals of moderate chronic or acute toxicity, and (3) chemicals of high chronic toxicity. **See Section 8.17 for the SOPs for working with these substances.**

7.8 UNKNOWNS

If you have a substance and are unsure of its ingredients, isolate the substance in a fume hood, obtain an "Unknowns" worksheet from the stockroom manager and fill in as much information as you can. Return the form to the stockroom manager. Do not move the substance until given permission, and do not use the fume hood until given permission.

7.9 DISPOSAL OF CHEMICALS

See Chapter 13. The accumulation, labeling, and temporary storage of hazardous wastes are regulated by the EPA Resource Conservation and Recovery Act (RCRA).

7.10 HOUSEKEEPING & INSPECTIONS

A principal cause of laboratory accidents is poor housekeeping. A clean work area is much safer than a cluttered or dirty one, and all lab employees must strive to maintain an orderly and safe laboratory setting. As an added safety precaution, laboratory personnel should be considerate and aware of housekeeping staff since the housekeeping staff workers generally are not as familiar with laboratory chemicals and their hazards as most laboratory workers.

7.10.a Inspections

"Formal housekeeping and chemical hygiene inspections should be held at least quarterly for units which have frequent personnel changes and semiannually for others; informal inspections should be continual."

29 CFR 1910.1450, Appendix A Section D.4(b)

(1) Formal housekeeping and chemical hygiene inspections will be conducted on a regular basis by the CHO and the Departmental Safety Committees.
(2) Informal housekeeping and safety inspections are to be conducted by the laboratory supervisors on an ongoing basis. Supervisors must keep constant vigilance to ensure a safe working environment.
(3) See the Laboratory Inspection Sheet (Appendix E) for further information on what to examine during inspections.

7.10.b General Housekeeping Practices

(1) Access to emergency equipment, showers, eyewash stations, and exits must never be blocked.
(2) Keep all work areas, and especially work benches, clear of clutter and obstructions. Properly store items when not in use.
(3) Do not place chemicals within two inches of the edge of a workbench.
(4) Chemicals must be stored properly (Section 7.6), and must not be stored in fume hoods, aisles, stairwells, on desks or workbenches, on floors or in hallways, or left on shelves over the workbenches.
(5) Never stack chemicals in the laboratory.
(6) Keep all aisles, hallways, and stairs clear of all chemicals and other obstructions; *never store or place chemicals on the floor*.
(7) Coats, bags, and other personnel items must be stored in the proper area, not on the benchtops, or near chemicals or equipment that is in use.
(8) All working surfaces and floors should be cleaned regularly.
(9) Keep all floors and work surfaces dry.
(10) Promptly clean up all spills, including water spills and ice, and properly dispose of all spilled chemicals (Chapter 10).
(11) Clean up work areas at the end of the operation or day.
(12) Keep drawers and cabinets closed to avoid accidents.
(13) To avoid the presence of noxious fumes arising from the sewer lines, each Laboratory Supervisor should ensure that a liter of water is poured down each laboratory drain at least monthly to ensure that the drain trap is functional.
(14) Hallway doors of all laboratories must remain closed to maintain the proper negative airflow from the hallways into the labs.
(15) Promptly dispose/recycle packing materials and empty cartons.
(16) Inspect faucets to see that they work properly and do not drip.
(17) Make sure that hose/tubing connections on faucets and other items are secure, and that hose/tubing is not brittle. Immediately replace any old or degraded hose/tubing.

7.10.c Glassware and Sharps (e.g., needles and blades)

(1) Make sure that disposal containers for broken glass and sharps are well labeled and placed in low-traffic areas.
(2) Properly dispose of broken glassware and sharps. If these items are contaminated with a hazardous substance, they need to be treated as hazardous waste and disposed in the appropriate waste container (Chapter 10).
(3) Never use cracked or chipped glassware; promptly discard these items in the broken glass container.
(4) Never stack beakers, flasks, etc.
(5) Handle and store glassware and sharps carefully.
(6) If glassware is stored on open shelving, there must be a 3/4" lip on the shelf, or some other type of guard, to keep the glassware from falling off the shelf.
(7) Wear appropriate gloves to clean glassware; do not pile up dirty or clean glassware.

(8) Wash glassware carefully (dirty water can hide glass fragments).

7.10.d Electrical Equipment

(1) Electrical equipment should be maintained by trained individuals only.
(2) Never overload circuits; use surge protection power strips and Ground Fault Circuit Interrupters as needed.
(3) Properly ground all electrical equipment.
(4) Be sure that all cords are well placed, in good shape, and away from water. Keep cords out of aisles.
(5) Immediately report any electrical failure or suspicious heating of equipment to the stockroom manager.
(6) Refer to Chapter 6 of "Prudent Practices" (http://darwin.nap.edu/books/0309052297/html/107.html) for guidelines for handling assorted electrical laboratory equipment.

7.11 LABORATORY-SPECIFIC STANDARD OPERATING PROCEDURES

Many labs conduct unique activities or use chemicals that are not commonly found in all labs. In such cases, these laboratories must have lab-specific Standard Operating Procedures that are present in hard-copy form.

7.11.a Lab-Specific SOP's:

(1) Each laboratory supervisor is responsible to have, in the lab, written laboratory policies and procedures that include a description of specific safety practices for that particular procedure or chemical. This written policy/procedure can range from an in-house typed worksheet to information that has been taken directly from a published reference (with appropriate acknowledgement and permission from the author).
(2) Each laboratory supervisor is responsible to make sure that all employees are properly trained in the lab-specific policy/procedure.
(3) Employees must read and understand these policies/procedures before beginning a procedure for the first time.

7.12 WORKING WITH LABORATORY EQUIPMENT

Refer to Chapter 6 of "Prudent Practices" (http://darwin.nap.edu/books/0309052297/html/107.html) for guidelines for handling assorted laboratory equipment. Since most laboratory equipment is electrically powered, Prudent Practices covers such equipment in some detail.

CHAPTER 8

"Hazardous Substances: Categories, Examples, and Standard Operating Procedures for Proper Use"

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

(i) 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)(3)(ii)

8.0 INTRODUCTION

This Chapter (modified from the University of Minnesota Department of Chemistry *Chemical Hygiene Plan*, http://www.chem.umn.edu/services/safety/safety.html) includes the Categories & Definitions of hazardous chemicals, and Standard Operating Procedures (SOPs) that are necessary when working with hazardous chemicals.

8.0.a IMPORTANT – Read CHAPTER 7 before continuing.
Before consulting the appropriate Standard Operating Procedure presented in this chapter, the "Basic Rules and Procedures for Working with Chemicals" (Chapter 7) MUST be read and understood.

8.0.b Follow the SOPS.
The SOPs describe fundamental safety precautions and measures beyond the general laboratory safety practices (Chapter 7) that the laboratory worker must follow to minimize the risk associated with potential hazards. These SOPs must be familiar to all laboratory workers, and must be followed at all times.

8.0.c Enforce the Exposure Limits.
Many substances can be hazardous simply by being exposed to the atmosphere because the toxic vapors can then come in contact with or be absorbed into a person's body. Therefore most materials used have some guidelines for exposure, such as ACGIH's Threshold Limit Values (TLV) and OSHA's Permissible Exposure Limits (PEL). *The exposure guidelines are presented in Chapter 5.* ***It is the responsibility of the laboratory supervisor to ensure that the PEL or TLV for a specific chemical is not exceeded.***

8.1 CATEGORIES OF HAZARDOUS CHEMICALS (This section is reproduced from Section 5.1)

8.1.a Definition of "Hazardous Chemical"

(1) The OSHA Laboratory Standard defines 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 principles that acute or chronic health effects may occur in exposed employees" (29 CFR 1910.1450(b)).
(2) In addition, *the worker should be aware that it is possible that a substance may be both a potential physical and health hazard.*
(3) The OSHA list of Hazardous Chemicals can be found online at http://www.cdc.gov/od/ohs/manual/chemical/chmsfapp2.htm#osha2.

8.1b Physical Hazards

The OSHA Laboratory Standard (29CFR 1910.1450(b)) considers a chemical a physical hazard if it falls into one of the following categories. Refer to Section 8.2-8.11 for Definitions and SOPs.

(1) Oxidizers (Section 8.2)
(2) Combustible Liquids, or Flammables (Section 8.3)
(3) Explosives (Section 8.4)
  (a) Shock- Sensitive (Section 8.4)
  (b) Organic Peroxides & Peroxide-Forming Substances (Section 8.5)
  (c) Dusts, Explosive Boiling (Section 8.6)
(4) Reactives
  (a) Incompatibles (Section 8.7)
  (b) Pyrophorics (Section 8.8)
  (c) Water-Reactives (Section 8.9)
(5) Compressed Gases (Section 8.10)
(6) SOPs for Cryogens and Liquified Gases are included in Section 8.11.

8.1c Health Hazards

The OSHA Laboratory Standard (29 CFR 1910.145(b)) considers a chemical a health hazard if it falls into one of the following categories. Refer to Section 8.12-8.17 for Definitions and SOPs.

(1) Corrosives (Section 8.12)
(2) Irritants (Section 8.13)
(3) Sensitizers & Allergens (Section 8.14)
(4) Carcinogens (Section 8.17)
(5) Toxic or Highly Toxic Substances (Section 8.17)

(6) Reproductive Toxins (Section 8.17)
(7) Hepatotoxins (Section 8.16)
(8) Agents which act on the hemotopoietic systems (various sections)
(9) Agents which damage the lungs, skin, eyes, or mucous membranes (various sections)
(10) SOPs for Asphyxiants are included in Section 8.15.

8.1.d Health Hazards – Additional Information

Prior to using substances classified as health hazards, it is essential that the risks associated with these chemicals be well understood:

(1) All such substances can potentially have adverse effects on living systems depending on the duration of exposure, frequency of exposure and the inherent toxicity of the particularsubstance.
(2) Toxic effects can be acute, causing damage after a single short duration exposure, or chronic, causing damage either after repeated or long duration exposure or a long latency period. Some chemical s may have both acute and chronic toxic effects.
(3) It is highly possible that a specific chemical may exhibit several adverse health effects, and it is then necessary to consult all appropriate procedures.
(4) **It is the responsibility of the laboratory supervisor to ensure that the PEL or TLV for a specific chemical is not exceeded. See Chapter 5 for details.**

8.1.e Particularly Hazardous Substances

The OSHA Laboratory Stand (29 CFR 1910.14450(e)(3)(vii)) considers certain classes of Health Hazards to be "Particularly Hazardous." These three classes of substances are 'Select Carcinogens,' 'Reproductive Toxins,' and 'Substances that have a High Degree of Acute Toxicity.'

(1) Provisions for additional protection for personnel working with these substances are required.
(2) Refer to Section 8.17 for Definitions & SOPs.

8.1.f The "Dirty Dozen" Substances

According to "Prudent Practices" it is generally recognized that certain substances tend to be responsible for more than their share of accidents. These substances have earned the nickname of the "Dirty Dozen."

(1) See Section 5.3.c for a list of the Dirty Dozen and their most common harmful effects.
(2) Inappropriate mixing or handling of certain compounds can also produce hazardous toxic gases. Individual laboratories are encouraged to prepare their own list of additional "Dirty Dozen" substances as part of their laboratory-specific Standard Operating Procedures.

8.2 – 8.11 Physical Hazards

8.2 OXIDIZERS

8.2.a Definitions and other Important Information

(1) **Oxidizer**. A "chemical other than a blasting agent or explosive [as defined in 29 CFR 1910.109(a)] that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases." 20 CFR 191.1450(b).
(2) **Perchloric Acid and Perchlorates.** These are particularly powerful oxidizing agents. Perchloric acid has the potential for undergoing explosive reactions with organic compounds and reducing agents. perchloric acid, perchlorate esters and transition metal perchlorates are capable of exploding.
(3) Oxidizing agents are potential fire and explosive hazards. They may react violently when in contact with reducing materials. Sometimes they also undergo a violent reaction with ordinary combustibles and trace metals.
(4) **Corrosive Properties**. Oxidizers tend to be corrosive. See Section 8.11 for information.

8.2.b Examples

(1) Refer to Table 2 (Appendix A) for an incomplete list of oxidizers.

8.2.c Standard Operating Procedures

(1) Know the reactivity of the materials being used in the process.

(2) If the reaction is potentially violent or explosive a safety shield must be used, or the reaction must occur in a hood with the sash pulled own completely.
(3) Use the minimum amount of material necessary for the procedure.
(4) Segregate oxidizers from flammable or combustible materials and from reducing agents.
(5) Liquid oxidizers should be stored in a secondary container that is large enough to hold the contents of the reagent container.
(6) Oxidizers must be labeled, dated and inventoried when received. The label should state: DANGER! OXIDIZING AGENT HIGHLY REACTIVE.
(7) Perchloric acid should only be used in a water wash-down perchloric acid fume hood.
(8) Perchloric acid should not be used near wooden tables or benches.
(9) When adding perchloric acid to organic material, the organic matter should first be digested with nitric acid.
(10) Do not heat perchloric acid with sulfuric acid. Heating with sulfuric acid may produce anhydrous perchloric acid which is explosive.
(11) Store perchloric acid properly.

8.3 FLAMMABLES AND COMBUSTIBLES

Flammable and combustible substances are routinely used in most laboratories, and may be solids, liquids, or gases. These substances release vapors, and it is the vapors that can ignite and are therefore a common source of fire hazard. Gases pose special hazards since leakage or escape of the gas can produce an explosive atmosphere in the laboratory.

8.3.a Background Information and Examples

(1) **Flash Point**. The flash point is the lowest temperature at which an ignition source can cause the chemical to ignite momentarily. Although the lowest temperature at which the chemical will catch fire with an ignition source is called the "fire point," it is rarely more than one or two degrees greater than the "flash point." Many common solvents have flashpoints that are lower than room temperature, making them potentially dangerous. Therefore, the flash point will be used as the reference of "Fire Hazard" at St. Olaf College.
(2) **Conditions that will Cause a Fire.** In order for a fire to occur, the following conditions must be met:
   (a) The concentration of the vapor must be between the upper and lower explosion limit (UEL, LEL).
   (b) An oxidizing material (e.g. oxygen in the room) must be present.
   (c) A source of ignition must be present. (e.g. with a standard hot/stir plate, every time the controls are turned on/off a small spark is emitted).
   (d) Spontaneous Combustion. As defined in "Prudent Practices" autoignition can take place when a substance reaches its ignition temperature without the application of external heat. Examples of materials susceptible to spontaneous combustion include oily rags, dust accumulations, organic materials mixed with strong oxidizing agents (e.g., nitric acid, chlorates, permanganates, peroxides, and persulfates), alkali metals (e.g., sodium and potassium), finely divided pyrophoric metals, and phosphorus.
(3) Refer to Table 3 (Appendix A) for a list of chemicals with low flash points (< 32 °C; < 89.6 °F).

8.3.b Primary Guidelines

(1) Chemicals with either of the following conditions will be considered a fire hazard:
   (a) An NFPA rating of ≥ 2 in the red category.
   (b) A flash point < 200° F (93.3°C) if the NFPA rating is not given.
(2) Chemicals that are considered a fire hazard will be:
   (a) Stored in a flammable solvent storage area or flammable storage cabinet, and
   (b) Used in a vented fume hood, away from sources of ignition.
   (c) Open "Immediate Use" containers (e.g., beakers) with small quantities of flammables (≤ 250 ml) that have an NFPA rating of ≤ 3 can be used on the laboratory countertops.
(3) Proper PPE must be worn at all times, and might include a flame retardant lab coat and face shield (over the safety goggles) if the conditions warrant.

8.3.c **Definitions**. NFPA and OSHA have definitions to determine when a chemical is considered flammable or combustible. These guidelines are herein adopted for use in the laboratory.

(1) **NFPA 704 Fire Hazard Ratings**. Probably the quickest way to assess the risk associated with flammable substances is to use the NFPA fire hazard ratings. These ratings are based on the severity of the fire hazard and the following criteria apply:

(a) **0** Substance **will not burn** under typical fire conditions.

(b) **1** **Flashpoint ≥ 93.4°C**
Flashpoint ≥ 200°F
Substance requires considerable preheating, under ambient temperature conditions, before ignition and combustion can occur.

(c) **2** **93.4°C > Flashpoint ≥ 37.8°C**
200°F > Flashpoint ≥ 100°F
Substance must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.

(d) **3** **37.8°C > Flashpoint ≥ 22.8°C** **or [(22.8°C > Flashpoint) and (Boiling Point ≥ 37.8°C)]**
100°F > Flashpoint ≥ 73°F **or [(73°F > Flashpoint) and (Boiling Point ≥ 100°F)]**
Substance can be readily ignited under almost all ambient temperature conditions.

(g) **4** **22.8°C > Flashpoint and 37.8°C > Boiling Point**
73°F > Flashpoint and 100°F > Boiling Point
Substance will rapidly or completely vaporize at ambient temperature and will burn readily.

(2) **OSHA Definitions**. The following definitions will also be followed:

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

(b) **flammable solid –** a solid that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard.

(c) **flammable gas –** a gas that, at ambient temperature and pressure, forms flammable mixture with air at a concentration of 13 percent by volume or less, or forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

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

(e) **flash point** – the lowest temperature at which a liquid has a sufficient vapor pressure to form an ignitable mixture with air near the surface of the liquid.

(d) **ignition temperature** – the minimum temperature required to initiate or cause self-sustained combustion independent of the heat source.

(e) **limits of flammability** – the range of concentrations in mixtures of air that will propagate a flame and cause an explosion.

8.3.d **Standard Operating Procedures.** The following SOPs must be followed when working with flammable or combustible substances:

(1) Know the flammability properties of the chemicals being used. Pay particular attention to substances with NFPA fire hazard ratings of 3 or 4.

(2) Containers must have the required identifying labels. See Section 7.4

(3) The amount of flammable/combustible materials in the open in the laboratory shall be kept to the minimum necessary for the work being conducted. Never exceed the storage limits imposed by NFPA Standard No. 45 ("*Standard on Fire Protection for Laboratories Using Chemicals, 2000 Edition*") and 29 CFR 1910.106 ("*Flammable and Combustible Liquids*").

(a) Within laboratories, storage of flammable liquids (including wastes) outside of approved flammable storage cabinets or safety cans (i.e., open shelves) must not exceed 10 gallons per 100 square feet of laboratory space.

(b) For the maximum amounts allowed in a laboratory see Table 4 (Appendix A).

(4) Eliminate ignition sources from areas where flammable substances are handled or stored. Ignition sources include electrical equipment, open flames, static electricity, and hot surfaces.

(5) When heating flammable materials:

(a) Never use an open flame.

(b) Use heat sources such as steam baths, water baths, oil baths, heating mantles or hot air baths.
(c) Never heat a closed container (even in a microwave).
(d) Heat open containers only in a fume hood, with the sash pulled down completely.

(6) When transferring flammable liquids from one container to another:
(a) The preferred method is to transfer substances within a fume hood.
(b) If transferring from one metal container to another metal container, ground both containers (to avoid static sparks).
(c) Avoid transferring from one plastic container to another plastic container since they require special grounding techniques.

(7) Before introducing flammable gases into a reaction vessel, the equipment should be purged either by evacuation or with an inert gas.

8.4 EXPLOSIVES

Special precautions must be taken in handling explosive materials. Explosions result when a substance undergoes a rapid reaction resulting in a violent release of energy. Explosive materials are those substances that either detonate or deflagrate. Many factors including heat, light, mechanical shock, and certain catalysts may initiate explosive reactions. Gases and fumes resulting from explosions may also have health hazards associated with them.

8.4.a Definition

(1) **Explosive.** A "chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature." (29CFR 1910.1450(b))

8.4.b Examples

(1) Refer to Table 5 (Appendix A) for an incomplete list of classes of explosive compounds and their associated functional group.
(2) Refer to Tables 6 & 7 (Appendix A) for examples of shock-sensitive compounds.

8.4.c Standard Operating Procedures. If it is necessary to work with explosive or highly reactive materials, the following guidelines must be adhered to:

(1) **Prior Approval** must be obtained.
(2) Before working with explosive or potentially explosive substances, the hazards associated with the substances and any specific safety precautions must be known.
(3) Relevant literature must be consulted, and the procedures must be discussed/"walked thru" before any activities takes place.
(3) Explosive chemicals should be brought into the laboratory only as required.
(4) Use the minimum amounts necessary for the procedure.
(5) Potentially explosive substances should be labeled, dated and inventoried when received. The label must include: DANGER! EXPLOSIVE MATERIAL
(6) All potentially explosive liquids must be stored in secondary containment trays large enough to hold the contents of the container.
(7) Proper PPE, including a flame retardant lab coat, face shield (over goggles), and heavy leather gloves must be worn at all times. A portable safety shield must also be used.

8.5 ORGANIC PEROXIDES AND PEROXIDE FORMING SUBSTANCES

8.5.a Definition and other Important Information

(1) **Organic Peroxide**. An "organic compound that contains the bivalent –O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide, where one or both of the hydrogen atoms has been replaced by an organic radical." (29CFR 1910.1450(b))
(2) Organic peroxides are one of the more hazardous classes of chemicals commonly found in the laboratory. Generally they are low-power explosives, but they are extremely sensitive to shock, sparks, and other forms of accidental ignition.
(3) Organic peroxides are highly flammable.

(4) There are also many potentially hazardous compounds that auto-oxidize when exposed to air and form hydroperoxides and peroxides.

8.5.b Examples

(1) The most commonly used peroxide-formers in use at St. Olaf are Tetrahydrofuran (THF) and Diethyl Ether.
(2) Refer to Table 8 (Appendix A) for an incomplete list of compounds that are known to form peroxides.

8.5.c Standard Operating Procedures

(3) Write the Date Opened on the jar. Any jar found without such a date will be promptly processed for disposal.
(4) Purchase and use only chemicals that contain peroxide-inhibitor additives (St. Olaf recognizes that there is a limited need for small quantities of ultra-pure chemicals that do not contain peroxide-inhibiting additives).
(5) Purchase substances in small enough jar sizes that, when opened, will be used in less than 3 months.
(6) Do not return unused chemicals to the original container.
(7) All spills involving peroxides should be cleaned up immediately. Solutions of peroxides can be absorbed on vermiculite or other absorbing material.
(8) Inert solvents can be used to dilute peroxides, which reduces their sensitivity to shock and heat. Do not use aromatic solvents.
(9) Metal spatulas must not be used when handling peroxides.
(10) Sources of heat are not allowed near peroxides.
(11) Avoid forms of impact near peroxides.
(12) Do not use chemicals that have reached their expiration date; take these substances to the stockroom manager for prompt stabilization and disposal.

8.5.d Storage of Peroxide-Forming Chemicals

(1) Store the containers in a tightly closed, properly labeled container.
(2) Store in a flammables cabinet, away from light, heat, sources of ignition, oxidizers, and oxidizing acids.

8.5.e Testing for Peroxides

(Use the test strips that are kept in the Chemistry Stockroom freezer; follow the directions)

(1) Chemicals stored in the stockrooms and the Chemical Storage Facility will be tested by the stockrooms managers.
(2) Laboratory Supervisors are responsible for testing for peroxides in their research laboratories.
(3) <u>For bottles with inhibiting agents</u> added by the manufacturer:
    (a) Once a bottle is opened, it <u>must</u> be tested monthly for peroxides.
(4) <u>For bottles without inhibiting agents</u> added by the manufacturer:
    (a) Once a bottle is opened, it must be <u>tested every two weeks</u> for peroxides.
(5) Any jar found to have peroxide formation will have Hydroquinone or Butylated Hydroxy Toluene (BHT) added to the bottle (these are stabilizing agents), and monthly testing will continue.
(6) The following concentration guidelines apply:
    (a) If peroxide levels are < 50 ppm, then the solution is still ok to use.
    (b) If peroxide levels are ≥ 50 ppm, then the solution will be stabilized and processed for disposal.
    (b) Do not use the substance if there is any signs of crystal formation inside the jar; immediately inform the stockroom manager & CHO and do not move the jar.

8.6 DUSTS, EXPLOSIVE BOILING (taken from "*Prudent Practices*")

8.6.a Dusts

Suspensions of oxidizable particles (e.g., flour, coal dust, magnesium powder, zinc dust, carbon powder, and flowers of sulfur) in the air can constitute a powerful explosive mixture. These materials should be used with adequate ventilation and should not be exposed to ignition sources. Some solid materials, when finely divided, are spontaneously combustible if allowed to dry while exposed to air. These materials

include zirconium, titanium, Raney nickel, finely divided lead (such as prepared by pyrolysis of lead tartrate), and catalysts such as activated carbon containing active metals and hydrogen.

8.6.b Explosive Boiling

Not all explosions result from chemical reactions. A dangerous, physically caused explosion can occur if a hot liquid or a collection of very hot particles comes into sudden contact with a lower-boiling-point material. Sudden boiling eruptions occur when a nucleating agent (e.g., charcoal, "boiling chips") is added to a liquid heated above its boiling point. Even if the material does not explode directly, the sudden formation of a mass of explosive or flammable vapor can be very dangerous.

8.7 INCOMPATIBLE CHEMICALS

8.7.a Pay close attention to the combination of chemicals that are being used.

Incompatibles must be separated, since an inadvertent mixing/spill may result in the formation of substances that have a combination of both physical and health hazards associated with them.

8.7.b Examples

(1) Refer to Table 9 (Appendix A) for an incomplete list of incompatible chemicals.

8.7.c Standard Operating Procedures

(1) Know the hazards associated with incompatible substances used in the procedure, and know the possible characteristics of any new substance that could result from the inadvertent mixing/spill of original chemicals.
(2) **Storing Incompatibles**. Store incompatible chemicals properly as suggested in Table 10 (Appendix A).
(3) Use the minimum quantities necessary in the process.

8.8 PYROPHORICS

8.8.a Definitions and other Important Information

(1) **Pyrophorics.** Pyrophorics are substances that ignite spontaneously in contact with air or moisture.

8.8.b Examples

(1) Refer to Table 11 (Appendix A) for an incomplete list of Pyrophorics. Examples of pyrophorics include many finely divided metals, metal hydrides, alloys of reactive metals, low-valent metal salts and iron sulfides.

8.8.c Standard Operating Procedures

(1) Avoid contact with air or water
(2) Work in inert environments
(3) Store pyrophorics in inert environments and away from flammables
(4) Pyrophorics should be labeled, dated an inventoried when received. The label should state: DANGER! PYROPHORIC MATERIAL HIGHLY REACTIVE.

8.9 WATER REACTIVES

8.9.a Definitions and other Important Information

(1) **Water Reactives.** Substances that are classified as water reactive are those that react violently with water.
(2) Typically these materials result in a large evolution of heat when in contact with water, decompose in moist air and may violently decompose in liquid water.

8.9.b Examples

(1) Water Reactives include alkali metals, many organometallics, some hydrides, some anhydrous metal hydrides, nonmetal oxides and halides. Refer to Table 12 (Appendix A) for an incomplete list of Water Reactives.

8.9.c Standard Operating Procedures

(1) Keep away from moisture; store in air-tight containers in a dark, cool, dry place.
(2) Work in a fume hood.
(3) Wear protective acid resistant rubber or plastic clothing along with gloves and a face shield.
(4) The Class D fire extinguisher (in Chemistry Stockroom Office) must be readily available.
(5) Water reactive materials should be labeled, dated and inventoried when received. The label should state: DANGER! WATER REACTIVE MATERIAL HIGHLY REACTIVE.

8.10 COMPRESSED GASES & CYLINDERS

(adapted from the University of West Virginia Chemical Hygiene Plan, http://www.as.wvu.edu/chemistry/Chemical_Hygiene_Plan.htm)

Depending on the identity of the compressed gas, it can be both a possible physical and health hazard. The compression of a gas results in a large amount of potential energy. Therefore, compressed gas cylinders are high-energy sources that can act as a rocket or fragmentation bomb. If the gas is flammable there is also the possibility for a fire or explosion to occur.

The contained gases may also be reactive, corrosive, or toxic, so these properties must be considered when developing experimental procedures and designing apparatus.

The primary hazards of inert gas systems are ruptures of containers, pipelines, or other systems, and the potential of an inert gas to asphyxiate if released into a confined space in high concerntrations.

8.10.a Definition

(1) **Compressed Gas**. Any material or mixture having in the container either an absolute pressure greater than 276 kPA (40 lif/in2) at 21° C, or an absolute pressure greater than 717 kPA (104 lbf/in2) at 54° C, or both, or any liquid flammable material having a Reid vapor pressure greater than 276 kPA (401 lbf/in2) at 38 °C. (29 CFR 1910.1450(b))

8.10.b Standard Operating Procedures

(1) Know and understand the physical/health hazards, uses, and safety precautions of the gas and associated equipment before using a cylinder. Consult the MSDS or other appropriate reference material.
(2) The contents and hazard level of every cylinder must be clearly identified with a durable label. If the contents and hazard level are not clearly labeled, then you must not handle or use the cylinder.
(3) Do not remove or deface the product identification labels or decals, or change the cylinder color.
(4) No cylinder should be accepted that is not clearly identified.
(5) Leather gloves and safety glasses are recommended for handling cylinders; chemical splash-resistant goggles may be necessary depending on the contents.
(6) The **Laboratory Supervisor** must develop plans to cover any emergency situation that might arise; do not move or use a cylinder unless you have received proper training.
(7) The **Laboratory Supervisor** must provide proper training and instruction for all personnel who handle compressed gases (see Sections 8.10.c-f).
(8) Identify empty cylinders by using the ring tags, or by writing the letters “EMPTY” or “MT” near the top of the cylinder.

8.10.c While working with compressed gases that are flammable, corrosive, irritating or toxic, the following additional SOPs must be observed:

(1) Cylinders of all gases having a Health Hazard Rating of 3 or 4 and those having a Health Hazard Rating of ≥ 2 with no physiological warning properties must be stored and used in a continuously mechanically ventilated hood or enclosure.
(2) Wear chemical splash resistant goggles and (if appropriate) a full face shield.
(3) Do not store or use incompatible cylinders next to each other.

(4) When opening valves on irritating or toxic gases, it must be done in a fume hood or specially designed cabinet.
(5) The relief valve on cylinders of hazardous gases must vent to a hood or other safe location.
(6) Cylinders of flammable gases and cylinders of toxic or corrosive gases must be stored and used in a ventilated area as required by the NFPA Standard 45.
(7) No more than three gas cylinders with Health Hazard Ratings of 3 or 4 may be kept in a ventilated hood or enclosure.
(8) Use soapy water or approved explosimeters to detect for flammable gas leaks.

8.10.d Handling and Moving Cylinders

(1) Handle all cylinders with care. Have a firm grip before moving cylinders, and never underestimate the cylinder's weight or momentum.
(2) When moving cylinders:
  (a) Make sure the valve is closed and the cap is securely placed over the valve.
  (b) Use a cylinder cart, and do not drag or slide cylinders, even for short distances. Make sure cylinder is securely fastened to cylinder cart with the supplied strap or chain.
  (c) Use only the 4-wheel cylinder carts; do not use a 2-wheel hand-truck or dolly since this is an inherently risky method of transporting a cylinder.
  (d) Never drop cylinders or permit them to strike each other violently.
  (e) Do not allow others to ride with you in an elevator with a cylinder.
(1) Return all empty cylinders to the designated storage area by the SC loading dock doors. Secure the empty cylinders to the wall with the chain. All empty cylinders must be identified by writing the letters "EMPTY" or "MT" near the top of the cylinder, or by using a ring tag.
(2) Never tamper with any safety devices in valves or cylinders.
(5) Never use cylinders as rollers for moving other items.
(6) Shipment of a compressed gas cylinder that has been filled without the consent of the owner is a violation of federal law.

8.10.e Storing Cylinders

(1) Return all empty cylinders to the designated storage area by the SC loading dock doors. Secure the empty cylinders to the wall with the chain.
(2) Cylinders are delivered to the storage cage inside the SC loading dock, and they are secured inside the locked cage door by the delivery personnel. The cylinders are then moved by stockroom personnel to the cylinder storage cage in the room immediately next to the SC loading dock. Cylinders must be stored in an upright position and securely fastened within the cylinder storage cage. Remember to lock the cylinder storage cage door.

8.10.f Using Cylinders

(1) Cylinders must be securely fastened at all times, using a chain or clamp and belt, to a wall or anchored bench.
(2) Cylinders must not be used near sources of ignition, electricity, or heat.
(3) Cylinders must be used in well-ventilated areas.
(4) The cylinder valve should be accessible at all times (i.e., do not place items, even a towel, on a valve).
(5) A cylinder cap or regulator must always be attached to the cylinder. Never leave a cylinder with the valve exposed.
(6) Always open the cylinder valve slowly.
(7) Use check valves or traps to prevent backflow of water or other contaminants if backflow can occur into the cylinder. If backflow does occur, mark the cylinder "CONTAMINATED" and notify the supplier immediately.
(8) Gas lines leading from a compressed gas supply must be clearly labeled with the identity of the gas, the laboratory being served, and relevant emergency telephone numbers.
(9) When equipment is not operating or left unattended, the cylinder valve should never be left open. Release the pressure from equipment connected to the cylinder at the end of a task.
(10) Cylinders should never be emptied to a pressure below 172 kPA (25 psi).
(11) Empty cylinders of gas should never be refilled, and the regulator should be removed and replaced with the valve cap.

8.10.g Proper Use of Pressure Regulators

The following instructions are applicable to pressure regulators used when it is necessary to reduce the cylinder supply pressure to a lower pressure

(1) Regulators must be compatible with the cylinders and the specific gas. Do not use adapters.

(2) Most regulators are similar in appearance; however, a principal difference occurs at the inlet connection. It is important that the inlet connection of the regulator is properly mated with the supply valve connection. Checking proper mating will avoid putting the regulator into the wrong service. Inlet connection standards are established by the Compressed Gas Association (CGA).

(3) All pressure regulators should be equipped with spring-loaded pressure relief valves.

(4) **Selecting a Regulator**

(a) Select a regulator that is suited for the particular gas service. CGA valve outlets are noted for each gas and gas mixture, and the CGA inlet for the regulator must correspond.

(b) A single-stage regulator reduces the pressure from the main supply line pressure to the desired operating pressure.

(c) A two-stage regulator is actually two regulators combined to automatically give uniform regulation over a wider supply range.

(5) **Attaching the Regulator**

(a) Identify the regulator; check the label and inlet and outlet gauges. Ascertain that the high pressure gauge is suitable for the pressure of the cylinder or source system.

(b) Inspect the regulator for evidence of damage or contamination. If there is evidence of physical damage or foreign material inside the regulator, return it to the supplier.

(c) Inspect the cylinder valve for evidence of damage. Do not use if there is evidence of damage and inform the stockroom manager.

(d) Attach the regulator to the cylinder and tighten securely.

(e) Close the regulator by turning the adjusting knob to the full counterclockwise position. The regulator <u>must</u> be closed completely before opening the cylinder valve.

(6) **Opening the Cylinder Valve and Safety Checking the System**

(a) Make sure that the regulator adjusting knob is turned fully counterclockwise. Standing with the cylinder valve between yourself and the regulator, place both hands on the cylinder valve and open it slowly, allowing the pressure to rise gradually in the regulator.

(b) When the high pressure gauge indicates maximum pressure, open the cylinder valve fully.

(c) Always close the cylinder valve when it is no longer necessary to have it open. Do not leave it open when the equipment is not in operation.

(7) **Adjusting the Pressure & Precautionary Measures**

(a) Turning the adjusting knob clockwise, establish the required use pressure by referring to the low pressure gauge.

(b) Make sure that the cylinder valve is easily accessible.

(c) Never exchange the discharge (low-pressure) gauge for one of lower pressure. The gauge may rupture if the adjusting knob is unintentionally turned too far.

(d) Check diaphragm regulators for creep (leakage of gas from the high-pressure side when the low pressure side is turned off).

(e) Provide check valves if necessary. Gas from a high-pressure system may back up, so backpressure protection is needed to prevent damage to a regulator.

(8) **Removing the Regulator from Service**

(a) Close the cylinder valve.

(b) Vent the gases in the regulator and/or system by turning the adjusting knob clockwise to make certain that no pressure is trapped inside the regulator.

(c) After relieving all the gas pressure, turn the adjusting knob counterclockwise as far as possible.

(d) All low pressure equipment connected to sources of high pressure should be disconnected entirely or, if not, independently vented to the atmosphere as soon as the operation is completed or shut down for an extended period of time.

(e) Disconnect the regulator.

(f) If the regulator is to remain out of service, protect the inlet and outlet fittings from dirt, contamination, or mechanical damage.

(g) Replace the cylinder valve cap

8.10.h Basic Emergency Action Procedures Involving Gas Cylinders

The following guidelines, based on the four general compressed gas hazard categories, should be used in preparing your specific emergency response procedures. These guidelines should be used to assist you in making decisions. They are not intended to serve as a substitute for your own knowledge or judgment. They provide only the most vital information and may not be necessarily adequate in all situations.

(1) **Fire Emergency Methods**
   (a) Before working with any flammable material, first notify the CHO about the type of material being handled, and the best method to use in fighting that particular kind of fire.
   (b) In anticipation of an emergency, have self-contained, positive-pressure, breathing apparatus in the work area and in adjacent uncontaminated areas.
   (c) If an emergency should occur in which gas is burning, try to stop the flow of gas before extinguishing the fire. If the fire is extinguished before the gas is turned off, an explosive mixture with air may be formed, which could result in more extensive damage.
   (d) Consider the physical and chemical properties (specific gravity, solubility, reactivity, etc.) of the particular gas in relation to fire fighting measures to be employed.
   (e) The possibility of oxidizing gases, nonflammable toxic gases, or nonflammable corrosive gases being present in the area or being involved in a fire is another important safety consideration.
      (i) Develop procedures to eliminate or minimize the hazards associated with these products.
      (ii) If you attempt to fight such a fire, wear full protective clothing and a self-contained breathing apparatus.

(2) **Handling of Leaking Cylinders**
   (a) Most leaks occur at the valve used in the top of the cylinder. Areas that may be involved are:
      (i) Valve stem, threads, or outlet
      (ii) Safety device
   (b) If a leak develops, effect emergency action procedures and notify the supplier.
   (c) Never attempt to repair a leak at the valve threads or safety device.
   (d) Consult the supplier for instructions if the leak is located at the valve stem or valve outlet.
   (e) The following general procedures are for leaks of minimum size where the indicated action can be taken without serious exposure to personnel.
      (i) If a leak develops in a cylinder containing flammables, inerts, or oxidants, ensure that there is adequate ventilation to dissipate the gas.
      (ii) Move the cylinder to an isolated area (away from combustible material if it is a flammable or oxidizing gas) and post signs that describe the hazards and state warnings.
      (iii) Some corrosives are also oxidants or flammables, adding to the seriousness of the leak. If the product is corrosive, the leak may increase in size as the gas is released. Move the cylinder to an isolated, well-ventilated area and use suitable means to direct the gas into an appropriate chemical neutralizer. Post signs that describe the hazards and state warnings.
      (iv) Follow the same procedure for toxic gases as for corrosive gases. Move the cylinder to an isolated, well-ventilated area and use suitable means to direct the gas into an appropriate chemical neutralizer. Post signs that describe the hazards and state warnings.
      (v) If it is necessary to move a leaking cylinder through populated portions of the building, place a plastic bag, rubber shroud, or similar protection over the top and tape it (preferably with duct tape) to the cylinder to confine the leaking gas.
   (f) When the nature of the leaking product or the size of the leak constitutes a hazard, wear self-contained breathing apparatus and protective clothing.
   (g) Basic action for large or uncontrollable leaks should include the following steps:
      (i) Evacuation of personnel
      (ii) Rescue of injured personnel by properly trained personnel equipped with adequate protective clothing and breathing apparatus
      (iii) Fire-fighting action (by properly trained personnel)
      (iv) Emergency repair (by properly trained personnel)
      (v) Decontamination(by properly trained personnel)

8.10.i Dangers of Oxygen Deficient Atmospheres

Incidents have occurred where workers have lost their lives or been overcome by high concentrations of nitrogen gas or other “inert” gases. Oxygen is normally at a concentration of 21% in the atmosphere. The balance is nitrogen, with traces of other components. The presence of any additional gas in the air (other than oxygen) dilutes the oxygen concentration, creating an oxygen deficient atmosphere. As the oxygen

concentration is progressively lowered, the physiological effects are giddiness, mental confusion, loss of judgment, uncoordinated movements, weakness, nausea, fainting, and death.

(1) **Immediate Effects of Breathing Oxygen Deficient Atmospheres**
   (a) Blood that normally becomes enriched in oxygen in the lungs takes less than 10 seconds to reach the brain. Lung oxygen is washed out and replaced by gas (e.g., pure nitrogen) containing no oxygen.
   (b) Blood flowing through the lungs receives insufficient oxygen, as none has been inhaled. In fact, the blood gives up whatever residual oxygen it may be carrying.
   (c) Blood severely depleted in oxygen then flows to the brain, where tissues rapidly become oxygen deficient. The result is swift unconsciousness because brain tissue is the body component most sensitive to the lack of oxygen.
   (d) Mental failure and coma follow a few seconds later. Symptoms or warnings are generally absent, but even if present, the loss of mental competence and physical weakness, uncoordinated movements, or fainting prevents the victim from talking. Death follows in two to four minutes.

(2) **Effects of Continued Breathing of Oxygen Deficient Atmospheres**
   The effects of continued exposure to oxygen deficient atmospheres depend on various factors: the degree of oxygen deficiency; the degree of physical exertion; and individual health factors (e.g., smoker/non-smoker). Any exercise increases the body's requirement for oxygen. Consequently, symptoms of oxygen deficiency will occur more rapidly among persons who are exerting themselves than would be the case among persons at rest. Below are ***the signs and symptoms of breathing an oxygen deficient atmosphere while a person is at rest***:
   (a) Oxygen Content of Air: 15%-19%
   Decreased ability to work strenuously. May impair coordination and may induce early symptoms in persons with coronary, pulmonary, or circulatory problems.
   (b) Oxygen Content of Air: 12%-14%
   Respiration deeper, increased pulse rate, impaired coordination, perception, and judgment.
   (c) Oxygen Content of Air: 10%-12%
   Further increase in rate and depth of respiration, further increase in pulse rate, performance failure, giddiness, poor judgment, blueness of lips.
   (d) Oxygen Content of Air: 8%-10%
   Mental failure, nausea, vomiting, fainting, unconsciousness, ashen face, blueness of lips.
   (e) Oxygen Content of Air: 6%-8%
   8 minutes, 100% fatal; 6 minutes, 50% fatal; 4-5 minutes, recovery with treatment for all exposures.
   (f) Oxygen Content of Air: 4%
   Coma within 40 seconds, convulsions, respiration ceases, death.

(3) **Precautions**
   (a) Do not work in areas without sufficient ventilation when using compressed gas cylinders. Be aware that increases in gas consumption rate may require additional ventilation.
   (b) Do not rely on the absence of a visible plume as evidence of a normal air atmosphere. A vapor cloud or plume, created by condensing water vapor in the air, can be evidence of the release of cold gas vapors. As the gas warms to ambient temperature, the danger is still present, without the warning of the visible plume, unless adequate dilution of the inert gas has occurred.
   (c) Personnel must not work in or enter atmospheres containing less than 19.5% (as recommended by the CGA, NIOSH, and OSHA) unless equipped with a self-contained breathing apparatus. This is also true for rescue personnel who may be overcome by the same oxygen deficient atmosphere as the initial victim.

(4) **First Aid**
   (a) Persons suffering from lack of oxygen should quickly be moved to areas with normal atmosphere.
   (b) If the victim is not breathing, assisted ventilation should be the immediate step (and call 9-911). Give supplemental oxygen with ventilation if oxygen is available. Note: Coma due to lack of oxygen is not always fatal. CPR certification is offered free-of-charge to all SC faculty and staff.

8.11 CRYOGENIC SUBSTANCES AND LIQUEFIED GASES

8.11.a Definitions and other Important Information

(1) Cryogenic liquids have boiling points of less than –73 °C (-100 °F).
(2) Because cryogenic liquids are at such low temperatures and because of their large ratio of volume expansion from liquid to gas, the main hazards associated with using cryogenic liquids are:
    (a) Fire or explosion.
        (i) Vaporization of liquid hydrogen in an enclosed work area can create a flammable mixture with air. St. Olaf College does not use liquid hydrogen.
    (b) Pressure buildup.
        (i) All cryogenic liquids produce large volumes of gas when they vaporize. If these liquids are vaporized in a sealed container, they can produce enormous pressures that could rupture the vessel. Any liquid or even cold vapor trapped between valves has the potential to cause an excessive pressure buildup to the point of violent rupture of a container or piping, hence use of reliable pressure relief devices is mandatory.
    (c) Frostbite; Embrittlement of structural materials.
        (i) Because they are all extremely cold, cryogenic liquids and their cold "boil-off" vapor can rapidly freeze human tissue, and can cause many common materials such as carbon steel, plastics, and rubber to become brittle or even fracture under stress.
        (ii) Exposure to these cold "boil-off" vapors that is too brief to affect the skin of the face or hands can affect delicate tissues, such as those of the eyes.
    (d) Asphyxiation.
        (i) The potential for asphyxiation must be recognized when handling inert cryogenic liquids. Because of the high expansion ratios, air can be quickly displaced. Vaporization of all liquid cryogenics, except oxygen, in an enclosed work area can create an oxygen-poor atmosphere.
(3) When spilled on a surface cryogenic liquids tend to cover it completely and therefore cool a large area.

8.11.b Examples

(1) Liquid nitrogen, liquid helium, and dry ice are the only crygenic substances used in St. Olaf laboratories.

8.11.c Standard Operating Procedures

(1) Laboratory Supervisors must make sure that their laboratory workers are instructed and trained in the nature of cryogenic hazards and the proper steps to avoid them. This should include emergency procedures, operation of equipment, safety devices, knowledge of the properties of materials used, and personal protective equipment required.
(2) Always handle cryogenic liquids carefully. Skin contact with cryogenic liquids must be avoided.
(3) Label all containers appropriately.
(4) Work involving cryogens must be conducted in a well-ventilated area.
(5) Use containers that are designed for the pressures and temperatures to which they are subjected.
(6) Dewar flasks used for small amounts of material should have a dust cap over the outlet to prevent moisture from condensing and plugging the neck of the tube.
(7) All equipment and cylinders containing flammable or toxic liquefied gases should have a spring-loaded pressure release device.
(8) Liquid hydrogen must not be transferred in an air atmosphere.
(9) Liquid oxygen must be kept away from organic materials.
(10) Liquid nitrogen must not be kept in any rooms that are not connected to the building ventilation system.
(11) Equipment and systems should be kept scrupulously clean and contaminating materials (oil, grease, etc.) avoided as these may create a hazardous condition upon contact with cryogenic fluids or gases used in the system.

8.11.d Handling

(1) Chemical splash goggles must always be worn when handling liquefied gases and cryogenic liquids. If severe spraying or splashing may occur, a face shield should be worn for additional protection.
(2) Uninsulated objects containing cryogens must be handled with tongs, or fiberglass gloves. The gloves should be loose fitting to allow for rapid removal in case of a spill.
(3) Use tongs to withdraw objects immersed in a cryogenic liquid.

(4) Stand clear of boiling or splashing liquid and its issuing cold gas. Boiling and splashing always occur when charging a warm container or when inserting objects into the liquid. Always perform these operations slowly to minimize boiling and splashing.
(5) Never allow any unprotected part of your body to touch uninsulated pipes or vessels containing cryogenic liquids; the extremely cold material may stick fast and tear the flesh when you attempt to withdraw it. Even nonmetallic materials are dangerous to touch at low temperatures.

8.11.e Containers

The most common containers for laboratory use are the dewar or the liquid cylinder. Since heat leak is always present, vaporization takes place continuously. Rates of vaporization may be as low as 0.4% and as high as 3% of container content per day, depending upon the design of the container and the volume of the stored product. As there is always some gas present when using liquefied gases, container capacity should be designed to include an allowance for that portion which will be in the gaseous state.

(1) **Dewars**
This type of container is considered a nonpressurized container. Product may be removed by pouring from the smaller dewars. Product should be removed from dewars with a capacity ≥ 50-liters by means of low pressurization and a transfer tube. A dust cap over the outlet of the neck tube prevents atmospheric moisture from plugging the neck tube.

(2) **Cylinders**
The cylinder is an insulated, vacuum-jacketed container. Safety relief valves and rupture disks protect the cylinders from pressure buildup. Since these cylinders operate at pressures up to 250 psig, their design must comply with Department of Transportation (DOT) specifications.
Product may be withdrawn as a gas by passing liquid through a vaporizing coil, or as a liquid under its own vapor pressure.

8.11.f First Aid for Cold Burns

Tissue contact with cryogenic liquids produces damage similar to that associated with thermal burns and causes severe deep-freezing with extensive destruction of tissue. Seek medical attention promptly.

(1) Flush affected areas with large volumes of tepid water (41-46°C [105-115°F]) to reduce freezing. DO NOT APPLY HEAT.
(2) If it is not in the area involved, loosen any clothing that may restrict circulation.
(3) Cover the affected area with a sterile protective dressing or with clean sheets if the area is large, and protect the area from further injury.
(4) Note that frozen tissues are painless and appear waxy with a pallid yellow color. Tissues become painful and edematous upon thawing and the pale color turns to pink or red as circulation of blood is restored.
(5) Tissues that have been frozen show severe, widespread cellular injury and are highly susceptible to infections and additional trauma. Therefore, rapid rewarming of tissues in the field is not recommended if transportation to a medical facility will be delayed.
(6) If the body temperature is depressed, the patient must be warmed gradually. Shock may occur during the correction of hypothermia. Cardiac dysrhythmias may be associated with severe hypothermia.

8.12 – 8.17 Health Hazards

8.12 CORROSIVES

8.12.a Definitions and other Important Information

(1) A Corrosive is a chemical that:
   (a) causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact (OSHA, 29 CFR 1910.1200, App A)
   (b) has a pH<2.0, or > 12.5 (EPA, 40 CFR 261.22)

(2) **How Damage Occurs.** Corrosives erode the skin, so such injuries may be very slow to heal. Ingestion can cause immediate injury to the mouth, throat, and stomach and, in severe cases, can lead to death. Eyes are particularly vulnerable to injury, and inhalation of vapors or mists can cause severe bronchial irritation or damage.

(3) **Classes of Corrosives.** There are many classes of compounds that exhibit corrosive properties, and corrosive substances exist as solids, liquids and gases. Strong acids and bases (also called caustics), strong dehydrating agents, strong oxidizing agents, halogens, and nonmetal chlorides tend to be the most common corrosive chemicals in science laboratories.

(4) **Corrosive liquids** such as bromine, sulfuric acid, sodium hydroxide solutions and hydrogen peroxide solutions, tend to be especially dangerous since their action on skin occurs very rapidly.

(5) **Alkali metal hydroxides** (especially potassium hydroxide and sodium hydroxide) are very dangerous when allowed to come into contact with tissue, especially the eyes. They are less painful than the strong acids, but damage may extend to greater depths because the injured person may not be aware of the seriousness of the incident.

(6) **Corrosive gases or dusts** from corrosive solids can seriously damage the respiratory tract. Typical examples of corrosive gases include halogens (e.g., chlorine), ammonia and nitrogen dioxide.

(7) **Solids** such as sodium hydroxide, phosphorous and phenol can be very dangerous when allowed to come in contact with the skin, and dusts from corrosive solids can also seriously damage the respiratory tract.

(8) **Dehydrating Agents** such as sulfuric acid, sodium hydroxide, phosphorous pentoxide, calcium oxide, and glacial acetic acid can cause severe burns to the eyes or skin because of their strong affinity to water.

(9) **Hydrofluoric Acid** is recognized as a "Particularly Hazardous Substance" – follow all rules and procedures found in 8.12.e(3).

(10) **Nonmetal Chlorides** such as phosphorous trichloride and corresponding bromides react violently with water and are a common cause of laboratory accidents.

(11) **Halogens** (in addition to being toxic) are corrosive on contact with skin, eyes, and the linings of the respiratory system. Because they are gases they pose a greater danger, especially by inhalation, of coming in contact with tissue.

8.12.b Examples

(1) Refer to Table 13 (Appendix A) for a list of common corrosive materials.

8.12.c Standard Operating Procedures

(1) Minimize skin and eye contact by wearing chemical splash goggles, gloves that are resistant to the corrosive, and a lab coat. If appropriate also use a face shield or other protective apparel.

(2) Avoid inhalation of corrosives by working in a fume hood or other containment device when handling volatile corrosives (e.g., ammonia is a severe bronchial irritant).

(3) Always add acids to water, never the reverse. Add the agent to the water <u>slowly</u>, since splattering might occur when some types of corrosives are added to the water too quickly.

(4) **Types of Containers.** Attempt to purchase corrosives in plastic-coated containers, so that if they are dropped, the most likely result should be only a leak through the plastic coating instead of a dangerous splashing.

(5) Move corrosives in a hand-held bucket or (if numerous containers) on a chemically-resistant cart that has proper secondary containment.

(6) Do not allow others to ride in the elevator when moving corrosives between floors.

(7) In areas where corrosives are used and stored, an eyewash and safety shower must be readily available.

(8) All containers and equipment used for storage and handling of corrosives must be corrosion resistant.
(8) Containers of corrosives from incompatible classes must be segregated.
(9) Incompatible classes of corrosives must not be mixed.
(10) Hydrofluoric Acid. Never handle or use Hydrofluoric Acid unless all following requirements have been met:
  (a) You have been given the proper training.
  (b) You have the proper knowledge and spill-response agents (Calcium glauconate cream & calcium carbonate).
  (c) All personnel with whom you are working have also received the proper spill-response training.

8.12.d Storing Corrosives (See Table 9, Appendix A for an Incompatibility Guide of Chemicals)

Incompatible corrosives must be physically segregated (i.e., if two jars of incompatible chemicals break simultaneously, the chemicals must be stored in such a way so that the spilled chemicals cannot come in contact with each other). The best method is to store incompatible chemicals in separate secondary containment trays and on separate shelves so that one chemical cannot spill on top of an incompatible chemical.

(1) Store corrosives in secondary containment trays.
(2) Always physically segregate acids from bases – use 2° containment trays if jars are on the same shelf.
(3) Always physically segregate inorganic acids from organic acids (some inorganic acids, such as Nitric Acid, are oxidizers and will react with organic acids).
  (a) Always store Nitric Acid separately.
  (b) Some examples of other inorganic acids are Hydrochloric Acid, Hydrofluoric Acid, Sulfuric Acid, and Phosphoric Acid
  (c) Some examples of Organic Acids are Acetic Acid, Butyric Acid, Formic Acid, Picric Acid, and Acrylic Acid
(4) Perchloric Acid, Picric Acid and other strong oxidizing agents (e.g., chromic acid) require special handling and **Prior Approval** before even purchasing. These substances must be stored in glass (unbreakable) or other inert containers.
(5) Segregate oxidizing acids from flammable and combustible materials.
(6) Segregate acids from chemicals that can generate toxic gases on contact, such as sodium cyanide and iron sulfide.
(7) Segregate acids from active metals such as sodium, magnesium, and potassium.
(8) Segregate acids from solvents such as toluene and xylene.
(9) Large bottles (4L) must be stored in acid cabinets.
(10) Absorbents or neutralizers are readily available for acid spills.

8.12.e Emergency Procedures – Corrosives (see Chapter 11 for more details)

(1) In areas where corrosives are used and stored, an eyewash and safety shower must be readily available.
(2) **Chemical Burns.** In the event of skin or eye contact, immediately flush the area of contact with water for 15 minutes or longer to remove all traces of the chemical.
  (a) Remove all affected clothing & jewelry. Do not hesitate to use a safety shower if you deem it necessary.
  (a) Do not apply ointments (except for HF – see below), baking soda, ice, or gauze covering to the wound.
  (b) Seek medical attention immediately. If an eye is involved the person must be taken to an opthalmologist as soon as possible to determine if further treatment is needed.
(3) **Hydrofluoric Acid Exposure.** Hydrofluoric acid is an extremely corrosive liquid that can cause severe injury via skin and eye contact, inhalation, and ingestion. HF readily penetrates the skin and causes decalcification of the bones. Laboratory workers must know the first-aid procedures for HF exposure before beginning work with HF. In the event of contact with HF, first-aid must be started within seconds. Do NOT allow affected area to touch your body!!
  (a) Calcium gluconate gel (2.5% w/w) must be readily accessible in work areas where any potential HF exposure exists.
  (b) Immediately flush the exposed area with tepid water, remove contaminated clothing, and call 9-911.

(c) Apply the calcium gluconate gel after 5 minutes of flushing with water. If the calcium gluconate gel is somehow unavailable, continue flushing the exposed areas with water until medical assistance arrives.
(d) If ingested, immediately call 9-911 and the Poison Control Center (9-1-800-764-7661).
(e) If the vapor is inhaled, move the victim to fresh air and call 9-911.

8.13 IRRITANTS

8.13.a Definitions and other Important Information

(1) **Irritant.** A chemical which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact. (29 CFR 1910.1250)
(2) There are a large number of chemicals, both organic and inorganic, that are irritants.

8.13.b Examples

(1) Refer to Table 14 (Appendix A) for a list of irritants.

8.13.c Standard Operating Procedures

(1) Minimize skin and eye contact by wearing chemical splash goggles and appropriate gloves. If appropriate also use a face shield and other protective apparel.
(2) Avoid inhalation of irritants by working in a fume hood or other containment device when handling volatile irritants.
(3) An eyewash and safety shower must be readily available.

8.14 SENSITIZERS (ALLERGENS)

8.14.a Definitions and other Important Information

(1) **Sensitizer.** A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical (29 CFR 1910.1250)
(2) An allergic reaction to a chemical results from previous sensitization to the chemical or to a structurally similar one. The reaction can be immediate or delayed (e.g., contact with poison ivy) and, after sensitization occurs, can result from exposure to extremely small doses of the substance (e.g., formaldehyde).
(3) The tendency to become sensitized to a chemical differs widely among individuals. It is possible that an individual will exhibit an allergic response even if the recommended personal protective measures are taken. Individuals working with sensitizers should be aware of the signs and symptoms associated with allergic responses to chemicals that include red, swollen and itchy skin and eyes. Anaphylactic shock is an example of a severe immediate allergic reaction that can result in death if not treated quickly. Consult the MSDS for the specific sensitizer.

8.14.b Examples

(1) Refer to Table 15 (Appendix A) for a list of sensitizers.

8.14.c Standard Operating Procedures

(1) Consult the MSDS or other references before working with the specific sensitizer.
(2) Be aware of signs and symptoms associated with allergic responses to the sensitizer.
(3) Be aware if emergency responses to allergic reactions to the sensitizer.
(4) Avoid skin and eye contact by wearing chemical splash goggles and gloves. If appropriate also wear other protective apparel.
(5) Avoid inhalation by working in a fume hood or other containment device.

8.15 ASPHYXIANTS

8.15.a Definitions and other Important Information

(1) **Asphyxiant.** A substance that interferes with the transport of an adequate supply of oxygen to the vital organs.
(2) Simple asphyxiants are substances that literally displace oxygen from the air being breathed. It is therefore important to recognize that chemically inert and biologically benign substances can be extremely dangerous under certain conditions (such as a leaking nitrogen cylinder in a closed room).
(3) Other chemicals have the ability to combine with hemoglobin, thus reducing the capacity of the blood to transport oxygen. Carbon monoxide, hydrogen cyanide, and certain organic and inorganic cyanides are examples.

8.15.b Examples

(1) Acetylene, carbon dioxide, argon, helium, ethane, nitrogen, and methane are common simple asphyxiants.

8.15.c Standard Operating Procedures

(1) Consult the MSDS or other references for specific effects.
(2) Be aware of signs and symptoms associated with exposure.
(3) Be aware of emergency responses.
(4) Use only in properly vented work areas.

8.16 Neurotoxins & Toxins Affecting Target Organs

8.16.a Definitions and other Important Information

(1) **Neurotoxins** can induce an adverse effect on the structure or function of the central and/or peripheral nervous system, which can result in permanent damage.
(2) Other toxic substances found in the laboratory may have adverse effects on many different target organs including the circulatory system, lungs, skin, eyes, the liver, and kidneys in addition to the reproductive system. *Toxins affecting the reproductive system are treated in Section 8.17.*

8.16.b Examples

(1) Refer to Table 16 (Appendix A) for a list of neurotoxins and toxins affecting target organs.

8.16.c Standard Operating Procedures

(1) Consult the MSDS for specific toxicological effects of the neurotoxin.
(2) Be aware of signs and symptoms associated with exposure.
(3) Be aware of emergency responses.
(4) Avoid skin and eye contact by wearing eye protection, gloves and any other appropriate protective apparel.
(5) Avoid inhalation by working in a fume hood or other containment device.
(6) **Mercury.** Metallic mercury and mercury compounds are extremely toxic. Store mercury in airtight, plastic containers away from direct sunlight or heat. Trained personnel should clean up mercury spills. Whenever possible, use secondary containment devices to reduce the chance of a mercury spill.
(7) **Cyanides.** Do not allow cyanide solutions to be mixed with acids. Hydrogen cyanide, a lethal vapor, is produced when acids react with cyanides.
(8) **Sulfides.** Do not allow sulfides to become mixed with acids. Hydrogen sulfide is a lethal vapor.

8.17 PARTICULARLY HAZARDOUS SUBSTANCES

OSHA has noted that many laboratory workers use numerous chemicals that fall into this category. While industrial workers might use only one of a limited few such chemicals, laboratory workers are likely to use many such chemicals, and exposures would at least have an additive if not synergistic impact on risk.

8.17.a Categories and Examples. According to the Laboratory Standard (29 CFR 1910.1450(e)(3)(viii)) certain classes of hazardous substances are considered to be particularly hazardous. Provisions for additional protection for personnel working with these substances are required. These three classes of substances are:

(1) **"Select Carcinogen"** – Carcinogens are substances that are capable of causing cancer and are chronically toxic agents; e.g., they cause damage after repeated or long-duration exposure, and their effects may become evident only after a long latency period. Therefore, carcinogens are extremely insidious toxins since they may have no immediate apparent harmful effects. Those substances exhibiting the greatest carcinogenic hazard are referred to as "select carcinogens" and meet one of the following criteria (29 CFR 1910.1450(b)):

(a) It is regulated by OSHA as a carcinogen (http://www.cdc.gov/od/ohs/manual/chemical/chmsfapp2.htm#osha)

(b) It is listed under the category "Known to be Human Carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (http://ntp.niehs.nih.gov/ntp/roc/toc11.html)

(c) It is listed under Group 1 ("Carcinogenic to Humans") by the International Agency for Research on Cancer Monographs (ARC) (http://www-cie.iarc.fr/monoeval/crthgr01.html)

(d) It is listed in either Group 2A (http://www-cie.iarc.fr/monoeval/crthgr02a.html) or 2B (http://www-cie.iarc.fr/monoeval/crthgr02b.html) by IARC, or under the category "Reasonably Anticipated to be Carcinogens" by NTP (http://ntp.niehs.nih.gov/ntp/roc/toc11.html), and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(i) after inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages less than 10 mg/m^3.

(ii) after repeated skin application of less than 300 mg/kg of body weight per week.

(iii) after oral dosages of less than 50 mg/kg of body weight per day.

(2) **Reproductive/Embryo Toxins** – chemicals that affect the reproductive capabilities, including chromosomal damage (mutagens) and effects on fetuses (teratogens). Reproductive toxins can have adverse effects on both men and women. Many reproductive toxins are chronic toxins and, therefore, the effects may only become evident after repeated or prolonged duration exposures. Table 17 lists some examples of reproductive toxins.

(3) **Substances that have a High Degree of Acute Toxicity.** Compounds with a high degree of acute toxicity are those that have a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rates weighing between 200 and 300 grams each.

(a) **OSHA List of Reproductive Toxins and Highly Acute Toxic Materials** http://www.cdc.gov/od/ohs/manual/chemical/chmsfapp2.htm#toxin.

(b) **OSHA List of Extremely Hazardous Chemicals** http://yosemite.epa.gov/oswer/ceppoehs.nsf/Alphabetical_Results?openview.

(c) Table 18 (Appendix A) lists several examples of highly acute toxic materials.

(d) Table 19 (Appendix A) lists the Category 1 Gaseous Inhalation Hazards as listed by the DOT.

(e) Table 20 (Appendix A) contains a list of toxicity ratings/lethal doses based on ingestion amounts.

(f) **Exposure Limits.** For a relatively complete list of exposure limits to toxic and hazardous substances, including definitions of terms, refer to the following website at the University of Minnesota Department of Environmental Health & Safety: (http://www.dehs.umn.edu/safety/lsp/AppB.html).

(4) **Substances that have a High Degree of Chronic Toxicity.** Appendix A of the Laboratory Standard also recognizes that many substances can have high chronic toxicity. Users of such chemicals must also follow the General Rules outlined in Section 8.17.b. Examples of such substances include dimethylmercury, nickel carbonyl, other human carcinogens, or substances with carcinogenic potency in animals.

8.17.b General Rules

(1) **Designated Areas; Signs & Labels.** Establish "Designated Work Areas," "Designated Storage Area," and "Restricted Access" areas. These areas may include an entire laboratory, or an area of a laboratory, or a device such as a glove box or dedicated fume hood.

(a) Appropriate signage (including "Authorized Personnel Only – Designated Area for use of [name of hazard]") must be conspicuously posted at entrances to these work areas, and if necessary, the areas will be locked. Only personnel with special instruction on the hazards and safe handling of these substances will be permitted access to the areas.
(b) Equipment used for particularly hazardous substances should be isolated from general laboratory equipment.
(c) Vacuum pumps should be protected by high-efficiency scrubbers or HEPA filters and must be vented into an exhaust hood.

(2) **Inventory.** All Laboratory Supervisors are required to maintain a list of particularly hazardous substances, and categorize each substance as a "Select Carcinogen," "Reproductive Toxin," or "Compound with a High Degree of Acute Toxicity."

(3) **SOPs.** Laboratory Supervisors are required to post written lab-specific Standard Operating Procedures and Precautions for work with Particularly Hazardous Substances. All substance-specific SOP's must be submitted to the Chemical Hygiene Office to be kept on file.

(4) **Records.** In all experiments involving particularly hazardous substances, the following information must be recorded:
(a) The amounts of materials used.
(b) Dates of use.
(c) The names of workers involved.

(5) **PPE.** Proper gloves are mandatory. In addition, consult the MSDS, LCSS or other appropriate sources of information for required protective equipment and apparel (beyond what is already required for handling "normal" hazardous chemicals).

(6) **Ventilation.** Use of ventilation equipment such as a fume hood or glove box is mandatory for any substance that can generate dust, vapors, aerosols, or mist.

(7) **Prior Approval.**
(a) The laboratory worker must obtain permission from the laboratory supervisor prior to initiating any process involving Particularly Hazardous Substances.
(b) The Laboratory Supervisor must obtain permission from the Campus Chemical Health & Safety Committee prior to ordering and using any substance that is recognized to have a high degree of acute toxicity.

(8) **Secondary Personnel.** Assure that at least two people are present at all times if the compound in use has a High Degree of Acute Toxicity. Both persons must be properly trained in the use, hazards, and emergency response of the particular substance.

(9) **Amounts Used.** Work should be done with the smallest amounts possible.

(10) **Action Levels.** For substances that have Action Levels, requirements for medical and exposure monitoring become effective.

(11) **Procurement, Storage, and Moving.**
(a) Purchases of the chemicals will be restricted to minimal amounts necessary to prevent uninterrupted work.
(b) Store chemicals in unbreakable, closed, chemically resistant secondary containers with a label such as WARNING! CANCER SUSPECT AGENT.
(c) Store in a Designated Storage Area (that is labeled accordingly) in a cabinet or secondary containment tray. Store volatile chemicals in a ventilated storage area (under a lightly negative pressure).
(d) Movement of chemicals within and between lab spaces must be planned carefully.

(12) **Contaminated Waste** – Consult the MSDS, LCSS or other appropriate sources of information for toxicological properties, and special precautions. Procedures for the safe removal of contaminated waste must be written and posted in the Designated Work Area.

(13) **Noncontamination/Decontamination Procedures** must be written and posted in the Designated Work Area. These Procedures must include:
(a) Proper removal and disposal of PPE (this must occur <u>before</u> leaving the Designated Area).
(b) Proper washing of hands, forearms, face, and neck (this must occur <u>before</u> leaving Designated Area).
(c) Proper housekeeping, including decontamination of work surfaces (e.g., use of a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder).

(d) A written (and posted) requirement that all equipment (including PPE) must not be removed from the designated area without decontamination.

(14) **First Aid.** Ensure that the appropriate first-aid measures are readily available in the event of an exposure.

(15) **OSHA 13 Carcinogens (29 CFR 1910.1003).** In regard to implementation of the OSHA Standard for the 13 Carcinogens you must provide particular information on how your laboratory-specific standard operating procedures deal with the following:

(a) Set up and maintenance of the clean change rooms specified for use in conjunction with the regulated areas.

(b) The medical surveillance program that must be instituted in conjunction with the use of any of the 13 Carcinogens.

(c) 29 CFR 1910.1003 can be found at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10007

(d) The OSHA 13 Carcinogens are:
4-Nitrobiphenyl, Chemical Abstracts Service Register Number (CAS No.) 92933;
alpha-Naphthylamine, CAS No. 134327;
methyl chloromethyl ether, CAS No. 107302;
3,3'-Dichlorobenzidine (and its salts) CAS No. 91941;
bis-Chloromethyl ether, CAS No. 542881;
beta-Naphthylamine, CAS No. 91598;
Benzidine, CAS No. 92875;
4-Aminodiphenyl, CAS No. 92671;
Ethyleneimine, CAS No. 151564;
beta-Propiolactone, CAS No. 57578;
2-Acetylaminofluorene, CAS No. 53963;
4-Dimethylaminoazo-benezene, CAS No. 60117; and
N-Nitrosodimethylamine, CAS No. 62759

8.17.c Medical Surveillance

(1) If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance.

8.18 ANIMAL WORK WITH CHEMICALS OF HIGH CHRONIC TOXICITY

****** This Section is still under development***

8.18.a Access. Facilities with restricted access are required.

8.18.b Administration of the Toxic Substance.

(1) When possible, administer the substance by injection or gavage instead of in the diet.

(2) If administration is in the diet, use a caging system under negative pressure or under laminar airflow directed toward HEPA filters.

8.18.c Aerosol Suppression.

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

8.18.d Personal Protection.

(1) When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator).

8.18.e Waste Disposal.

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

CHAPTER 9

"Biological Safety"

This Chapter under development

St. Olaf Faculty/Staff follow all appropriate guidelines in the following:

1. ***Biosafety in the Laboratory: Prudent Practices for the Handling and Disposal of Infectious Materials***
   http://www.nap.edu/openbook.php?isbn=0309039754
2. ***Biosafety in Microbial and Biomedical Laboratories (BMBL) 5th Edition***
   http://www.cdc.gov/od/ohs/biosfty/bmbl5/bmbl5toc.htm

CHAPTER 10

"Radiation Safety"

(Jason Engbrecht, Radiation Safety Officer, January, 2007)

10.0 INTRODUCTION

Radioisotopes in Minnesota are regulated by the State of Minnesota (http://www.revisor.leg.state.mn.us/arule/4730/). The stated purpose of these regulations is (a) "to control the receipt, possession, use, transfer and disposal of licensed material" and (b) ensure that the "total dose to an individual…does not exceed the standards for protection" (10 CFR 20.1001). Thus, State Codes require that no isotopes may be obtained, used, or disposed without the required licenses and training. Moreover, these regulations specify specific procedures and limits (including record keeping) that must be met to ensure secure and safe use of radioisotopes.

Demonstration that these rules are actively in place are required to keep an institutional license: a licensee is subject to inspection at any time. Both government entities require a Radiation Safety Officer (RSO) to oversee the safe storage, use and disposal of materials. **Thus, anyone considering using isotopic materials must first contact the RSO (Dr. Jason Engbrecht; x2711, engbrecht@stolaf.edu).**

10.1 REQUESTING TO USE ISOTOPES

10.1.a Proposal. Anyone proposing to use radioisotopes is required to submit a written proposal to the RSO that contains the following information:

(1) Documented training of the PI in proper handling, use, and monitoring the relevant radioactivity.
(2) The isotopes, chemical form, amounts (mCi or Bq) to be used and total amount expected to be held on campus at any given time.
(3) A detailed protocol that covers storage location, use site(s), any procedures (chemical reactions, centrifugation, spectrophometry, chromatography, etc.), a waste collection plan (dry and liquid), a personal protection plan, a monitoring plan, and the expected duration of use. Direct reference to the appropriate government regulations is useful (see References 1 & 2 below).
(4) A lab-specific training and safety program for students that includes written standard operating procedures and an isotope specific exam to be completed by anyone using the isotope.

10.1.b Acceptance. The RSO will determine if the proposal is covered by an existing licensure and if the proposal meets St. Olaf standards for safety.

(1) If the proposal is reasonable, but not covered under the existing licensing, the RSO in consultation with the Chemical Hygiene Officer (CHO, Patrick Ceas), the relevant department chairs and Associate Dean, will determine the suitability of applying for an amended license.
(2) If the proposal seems reasonable to all parties, the RSO will make that application.
(3) Any grant proposal that includes isotopic use will require a signature from the RSO signifying that we are licensed to carry out this activity.

10.2 RESPONSIBILITIES

10.2.a Principle Investigator (PI). Once a given isotopic use has been licensed and permission has been granted, the PI is responsible for carrying out the work as described, logging use and location of the isotopes, and monitoring and maintaining lab safety for all personnel. Careful attention to these responsibilities is needed in order for each PI and the College to maintain its licenses with the State and the NRC. The PI will:

(1) Obtain in writing from the RSO clearance for any purchases or transfer of radioisotopes. (i.e., Purchase orders must be signed).
(2) Contact the RSO in writing prior to any changes in protocol, location, or amounts of isotope to be used
(3) Ensure that all materials are secured at all times and that storage sites are clearly posted with the relevant information.
(4) Implement the training and safety protocols described in their proposals.
(5) Provide all users with necessary personal safety items (gloves, lab coats, badges) and provide appropriate shielding in work areas, for stored materials and waste

(5) Conduct wipe tests or other appropriate monitoring each time isotopes are used. Monitoring should occur annually even if the isotopes are stored.
(6) Maintain an accurate and current log of usage and disposal.
(7) Report annually to the RSO with copies of use and monitoring records.
(8) Work with the RSO and CHO to ensure timely disposal of all waste.
(9) Secure the area and contact the RSO and CHO immediately in the event of an accident.

10.2.b Radiation Safety Officer.

(1) The RSO will provide an annual training program if there are to be a number of users.
(2) The RSO will meet with the PI(s) on a regular basis to ensure that all government regulations are being followed.
(3) The RSO may halt activities at any time if there is a reason to believe safety is compromised or government reporting requirements are not being met.

10.3 St. Olaf College Resources for Isotope Users

10.3.a Questions & Training. The RSO and CHO are happy to work with PIs in considering protocols, safety plans and any other aspect of isotopic use.

10.3.b Waste Labeling, Storage & Disposal. There is a secured site for storage of waste in RNS. Follow the procedures found on the University of Minnesota's Radiation Waste website: http://www.dehs.umn.edu/rpd/wasteindex.html.

(1) The RSO and CHO must be notified if you plan to store materials in this facility.
(2) All materials must be clearly labeled with the your name, date, isotope, amount (in mCi or Bq), all chemicals, the half-life (and if relevant, the date expected at which 10 half-lives will be complete). If it is in liquid form, the volume must be given.
(3) Scintillation vials must include the name of scintillation fluid and approximate total volume.
(4) All sharps (glass, needles) must be stored in protective containers.
(5) Incidental waste (diaper paper, gloves, kimwipes) may be stored in well-labeled heavy plastic bags.
(6) Disposal will be arranged on an annual basis depending on need.
(7) See the University of Minnesota Radiation Protection Division as a good resource for advice on safe waste handling and other matters: http://www.dehs.umn.edu/rpd/.

10.3.c Critical References for Isotope Users.

(1) U.S. Nuclear Regulatory Commission's (NRC) **Rules and Regulations**, as Title 10, Part 19 of the Code of Federal Regulations titled "Notices, Instructions, and Reports to Workers; Inspections" (10 CFR 19) and Part 20, titled "Standards for Protection Against Radiation" (10 CFR 20). The NRC regulations may be viewed via the Internet at http://www.nrc.gov/NRC/CFR/index.html.
(2) The State of Minnesota regulations regarding isotope use may be viewed at http://www.revisor.leg.state.mn.us/arule/4730/.
(3) The University of Minnesota's Office of Radiation Protection is a wealth of information. The main page is found at: http://www.dehs.umn.edu/rpd/.

10.4 DOCUMENTED TRAINING

We must have on file written documentation of training for all users and for all personnel (students, staff) who will work in the space where isotopes are stored and used. Without this documented training in our files, we would be in violation of the State and Federal Codes. The language below is to be used to document the training and must be attached to a copy of the written materials for all training events (even informal conversations with students). As noted above (10.1.a(4)), preparing these documents is required prior to granting an individual PI permission to use radioactive material. The specific training will depend on the circumstances: good sources include the UofM web site (http://www.dehs.umn.edu/rpd/) and "At the Bench: A Laboratory Navigator" (ISBN 0-87969-523-4; a copy is located in the BioMolecular Shared Research Space in SC 140).

"*I have read and understood all of the material written above. I have discussed this with my instructor and had opportunities to ask questions. I understand the importance of all of the safety precautions for the health and well-being of myself and others who work in or enter this space. I understand the containment and reporting procedures in the event of a spill. I understand that I am using regulated materials that may not be removed from the designated areas or shared with anyone else. I am willing to take the responsibilities described above.*

Signed: _____ *Date:* _____

Printed name: _____

I, as the supervising PI, have discussed the responsibilities and precautions associated with isotopic use with the individual named above. I believe that the individual understands the procedures and is able to undertake them.

Signed: _____ *Date:* _____

Printed name: _____

CHAPTER 11

"Animal Care and Use"

This Chapter under development

CHAPTER 12

"Controlled Substances"

This Chapter under development

CHAPTER 13

"Waste Disposal Program"

A Waste Disposal Program will be developed to "assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals."

29 CFR 1910.1450 Appendix A, Sect. D.11

13.0 INTRODUCTION: GOALS AND RESPONSIBILITIES

13.0.a Introduction.

St. Olaf College is required to manage hazardous wastes in a safe and environmentally sound manner by federal, state, and local regulations, and to that end the College participates in the University of Minnesota Chemical Safety Day Program (http://www.dehs.umn.edu/csdp/). The Chemical Safety Day Program (CSDP) is a cost-effective waste management program available to educational institutions and nonprofit organizations throughout the state of Minnesota. Collected waste is sent to the Thompson Center for Environmental Management (TCEM) at the University of Minnesota Twin Cities campus for processing and ultimately disposal.

13.0.b Goals of the Waste Disposal Program.

(1) **Protect Health & Safety.** Proper evaluation, labeling, segregation, storage, and packaging protects the health and safety of all persons handling hazardous chemical waste.

(2) **Reduce Hazardous Waste in the Laboratory.** The volume of hazardous chemical waste generated at the College is reduced by:

- (a) Aggressive pollution prevention at the source (e.g., product substitution and process modification - downsizing to microscale; neutralization of corrosives, etc.).
- (b) Recovery and reuse of certain hazardous chemicals.
- (c) Disposal of nonhazardous waste separately from hazardous chemical waste.
- (d) Redistribution of unused and reusable chemicals among teaching and research laboratories.
- (e) Timely collection of chemical waste from College laboratories.

(3) **Protect the Environment.** The CSDP provides a comprehensive, easy-to-use program for the proper redistribution, recycling, and disposal of unwanted chemicals. This reduces the amount of pollutants in our environment.

(4) **Comply with Government Regulations.**

- (a) Policies and procedures contained in this Chapter are in compliance with federal, state, and local regulations regarding the collecting, labeling, storage, transportation, and disposal of laboratory hazardous chemical waste at St. Olaf College.
- (b) As a member of the CSDP, St. Olaf College has adopted the relevant policies and guidelines put forward by the University of Minnesota in the Hazardous Chemical Waste Guidebook (http://www.dehs.umn.edu/hwd/guidebook/). Much of the written material in Chapter 10 of the St. Olaf CHP is modified from this Guidebook.

13.0.c Responsibilities.

(1) **Determining if a Substance is Hazardous Waste.** As individuals who have received off-campus training in the identification and management of hazardous wastes, the CHO and Stockroom Managers are the only individuals who make a final determination if chemicals used in the academic setting are considered waste and (by definition) hazardous waste. *Laboratory Supervisors and faculty researchers may make preliminary determinations, but the Stockroom Managers or CHO make the final determination.*

(2) **Waste Manifests & Storage.** The CHO oversees the manifesting and temporary storage of the waste materials. The Stockroom Managers are in charge of the actual data entry and proper labeling of the waste containers. St. Olaf College is a participant in the University of Minnesota Chemical Safety Day Program (http://www.dehs.umn.edu/csdp/), and the college follows all applicable rules and regulations set forth by the Program.

(3) **Laboratory Supervisors** are responsible for ensuring that they and their workers follow the guidelines presented in Chapter 10 concerning proper collecting, recording, and placement of substances that may eventually be designated as hazardous waste, and that their workers have received the proper training (from the CHO or Stockroom Manager).

(4) **Laboratory Workers** are responsible for following the guidelines presented in Chapter 10 concerning proper collection and placement of substances that may eventually be designated as hazardous waste.

13.1 How Will You Comply with Government Regulations? Follow These Guidelines

13.1.a The following is a summary of the steps that St. Olaf College and laboratory personnel must take to comply with federal, state, and local regulations for the handling of laboratory hazardous waste. Read the rest of Chapter 10 for specifics

(1) **Designate On-site Emergency Coordinators or Lab Safety Officers**. In addition to the CHO and stockroom managers, each department designates one person to be on-site emergency coordinator and one as backup emergency coordinator. These people should know what hazards exist in your area and how to implement the spill response plan (contingency plan) for the area. They will act as advisors to Police, Fire Department and Public Safety personnel.

(2) **Provide Proper Training to Laboratory Workers**.

(3) **Post Emergency Contact Information**.

(4) **Properly Label Hazardous Waste Containers**.
- (a) Each container must have the words "Hazardous Waste" clearly visible.
- (b) Each container must have a list of its contents. including percentages and water content.
- (c) Each container that is used to collect mixtures of chemicals must have the start date and (eventually) end date.
- (d) Each container must identify the course or research lab in which it was used/generated.
- (e) Each container must possess an appropriately filled out NFPA label.

(5) Keep Waste in Compatible Containers.
- (a) Containers and lids must be compatible with the waste chemicals stored in them.
- (b) Lids must be screw caps; stoppered or corked flasks/bottles are not acceptable for use as hazardous waste containers.

(6) **Keep Waste Containers <u>Closed</u> at all Times**. <u>Never</u> leave any container of waste open, even for only 5-10 minutes. This is one of the most common citations for colleges from regulatory inspectors.

(7) **Use Secondary Containment (Trays or Cabinets) for Liquid Waste**.

(8) **Segregate Incompatible Wastes**. Use the DDC (see Section 12.6) to segregate waste containers.

(9) **Keep Waste Containers only in Properly Designated Accumulation Areas.**
- (a) **Satellite Accumulation Points.** SAPs are specifically designated locations where we "accumulate hazardous waste at or near the point where it is initially generated and collected during daily operations" [40 CFR 262.34]. Once the container is filled it is moved to our Central Accumulation Point in RNS 108C.
- (b) Every laboratory in RNS is designated as SAPs. Rooms that have active SAPs have the location marked within the room, and this section of the room must be used for only the collections of wastes.

(10) **Inspect the Central Accumulation Room Weekly**. This is performed by the Chemical Hygiene Officer.

(11) **Hazardous Waste Can Not be Disposed by Evaporation, Sewer, or Trash**.
- (a) If a waste does not have the "xxNH" nonhazardous designation in Chemical Registry (see Section 13.4.a), then it is considered hazardous and can <u>not</u> be disposed of by <u>evaporation</u>, <u>sewer</u> or <u>trash</u>.
- (b) Do not sewer chemicals without approval of the CHO or Stockroom Manager.
- (c) Assuming no additional hazardous characteristics, liquids MUST be neutralized (pH between 5-9) before being sewered.
- (d) <u>Do</u> <u>not</u> <u>evaporate</u> <u>residual</u> <u>solvents</u> <u>or</u> <u>nearly-empty</u> <u>containers</u> <u>of</u> <u>liquids</u> <u>in</u> <u>a</u> <u>fume</u> <u>hood</u> in order to "empty" a container. Use condensers on all distillation and concentration procedures.

(12) **Notify the stockroom manager and CHO, and (if necessary) Public Safety, Facilities, and 9-911 in the Event of a Chemical Spill**.
- (a) Public Safety 24-Hour Emergency Dispatch telephone: -3666.
- (b) Facilities telephone: -3280.
- (c) Minnesota Pollution Control telephone: 9-1-800-422-0798.

(13) **Use Pollution Prevention Techniques to Reduce the Amount of Hazardous Waste Generated**.
- (a) Use microscale techniques, nonhazardous chemical substitutes, or process modification to reduce the amount of waste generated.
- (b) Contact your peers, professional organizations, or vendors to learn about the latest pollution prevention techniques.

(c) Return unused chemicals to the stockroom manager.
(d) Train your employees and students in pollution prevention techniques.

13.2 DEFINITION OF WASTE

St. Olaf College is not a commercial manufacturer of chemical products; therefore, on the basis of criteria set forth by the Environmental Protection Agency (EPA; 40 CFR 261.2) and the Minnesota Pollution Control Agency (Minn. Statutes 2004 Chapter 116.06 Subd. 22), ***waste is defined as a material that has been disposed, burned/incinerated, or accumulated/stored in lieu of being disposed, burned/incinerated***. Furthermore, a material from RNS is not considered waste until determined to be waste by the CHO or a stockroom manager.

13.3 DEFINITION OF HAZARDOUS WASTE

A waste chemical must be managed as a hazardous waste if it exhibits hazard characteristics or is specifically listed in certain federal or state regulations. On the basis of criteria set forth by the Environmental Protection Agency (EPA; 40 CFR 261.3, 40 CFR 261.20-24) and the Minnesota Pollution Control Agency (Minn. Statutes 2004 Chapter 116.06 Subd. 11; Minn. Rule 7045.0135), ***chemical waste is considered hazardous if it exhibits any of the following characteristics*:**

13.3.a Ignitability.

(1) Liquids, other than aqueous solutions containing less than 24% alcohol by volume, that have a flash point below 60° C (140° F).
(2) Non-liquids that are capable of causing fire by friction, absorption of moisture, or spontaneous chemical changes and, when ignited, burn vigorously and persistently to create a hazard.
(3) An ignitable compressed gas as defined under 49 CFR 173.115.
(4) Oxidizers such as chlorates, permanganates, inorganic peroxides, or nitrates that yield oxygen readily to stimulate the combustion of organic matter (49 CFR 173.127).
(5) Note: Dilutions of ethyl alcohol solutions at concentrations greater than 5% for sewage disposal purposes is prohibited by federal, state, and local regulations.

13.3.b Corrosivity.

(1) Aqueous solutions that have a pH ≤ 2 or ≥ 12.5 (Dept. of Transportation). However, wastes with pH ranges 2-6 and 11-12.5 are also managed as hazardous waste because of sewer discharge regulations and SARA Title III requirements.
(2) Liquids capable of corroding SAE 1020 steel at a rate greater than 6.35 mm/year at 55°.

13.3.c Reactivity.

(1) Substances that when mixed with water:
    (a) react violently or form potentially explosive mixtures.
    (b) generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.
(2) Substances that are normally unstable and readily undergo violent changes without detonating.
(3) Substances that contain cyanide or sulfide that, when exposed to a pH in the range between 2 and 12.5, generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment .
(4) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.
(5) It is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.
(6) It is a forbidden explosive as defined in 49 CFR 173.51, or a Class A explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CFR 173.88.

13.3.d Lethality. (As defined by MN Rules 7045.0131, Subpart 6)

(1) An oral LD_{50} of 500 mg/kg or less in rats.
(2) A skin absorption LD_{50} of 1000 mg/kg or less in rats.
(3) An inhalation LC_{50} of 2000 mg/m^3 or less for dusts or mists administered to rats.
(4) An inhalation LC_{50} of 1000 ppm or less for gases or vapors administered to rats.

13.3.e Toxicity.

(1) The Toxicity Characteristic Leaching Procedure (TCLP) is a standardized test that mimics rainwater leaching through solid waste and compares the amount of toxic constituents released by the leaching action to federally established standards. If the standard is exceeded, the waste is considered hazardous. Liquids are analyzed directly without adding the leachate material.

(1) For an incomplete list of known toxic chemicals see Appendix IV in the University of Minnesota Hazardous Waste Guidebook (http://www.dehs.umn.edu/hwd/guidebook/appendix4.html).

13.3.f EPA Listed Wastes.

(1) EPA and MPCA regulations also list approximately 450 commercial or off-specification chemicals, waste streams, or their spill residues which must be handled as hazardous wastes due to their acute or chronic toxicity.

(2) For a list of these EPA-listed chemicals see Appendix V in the University of Minnesota Hazardous Waste Guidebook (http://www.dehs.umn.edu/hwd/guidebook/appendix5.html).

13.3.g Other Criteria.

(1) In addition, St. Olaf College follows the protocol of the University of Minnesota, and has chosen to manage as hazardous waste certain chemicals that may not technically be considered hazardous waste under the hazardous waste regulations. Such chemicals have sufficient mutagenic, teratogenic, carcinogenic, or reproductive hazards that they warrant such special handling (e.g., ethidium bromide), and the CHO works with individual Laboratory Supervisors to determine how these wastes will be handled.

(2) In general, waste streams containing greater than 1 ppm of these wastes should either be deactivated in the laboratory or considered hazardous waste.

13.4 STEPS TO DECIDE IF YOUR WASTE IS HAZARDOUS

This is a very simple process. **Note**: as individuals who have received off-campus training in the identification and management of hazardous waste, *the Chemical Hygiene Officer & Stockroom Managers are the only individuals who make a final determination if chemicals used in the academic setting are considered hazardous waste*.

13.4.a Background Information: The Drum Designator Code (DDC).

(http://www.dehs.umn.edu/hwd/guidebook/appendix1.html)

(1) The DDC is an internal system developed by the University of Minnesota Chemical Waste Program to classify substances through a two-part designation code: the Hazard Class and the Disposal Type.

(2) **Hazard Class.** The first part of the DDC consists of two digits that designate the chemical's primary hazard as it relates to the Department of Transportation (not all sequential numbers are used):

01	Corrosive Bases	**06**	Combustibles	**12**	Organic Peroxides
02	Corrosive Acids	**07**	Flammable Gases	**14**	Explosives
		08	Flammable Liquids		
03	ORM-A (Other Regulated Materials-A)	**09**	Flammable Solids	**16**	Oxidizers
05	ORM-A (Other Regulated Materials-A)	**11**	Non- Flammable Gases	**18**	Poisons

(3) **Disposal Type.** The second part of the DDC consists of two letters that further describe the chemical/physical characteristics of the substance, or defines the type of disposal or treatment methodology required.

NH NonHazardous – dispose in regular sewage or trash

BS	Bulkable Solvent	**HP**	Pesticide	**PX**	PCB Contaminated
CG	Compressed Gas	**LI**	Liquid Inorganic	**RX**	Radioactive Material
CL	Chlorinated Organic Liquid	**LO**	Liquid Organic	**SC**	Sulfuric/Chromerge
CN	Cyanide	**NA**	Nitric Acid	**SI**	Solid Inorganic
CS	Chlorinated Organic Solid	**PA**	Poison A	**SO**	Solid Organic
DX	Dioxin Containing	**PB**	Poison B	**SS**	Shock Sensitive
EX	Explosive	**PI**	Poisonous Inorganic	**TS**	Trade Waste Incinerator
FB	Fuel Blending	**PF**	Peroxide Former	**WS**	Water Sensitive
HM	Heavy Metal	**PO**	Pourable Oil		
FL	Flammable Liquid	**FS**	Flammable Solid		

13.4.b Follow these Steps to Decide if Your Waste is Hazardous.

(1) Go to the UM Chemical Waste Registry (http://www.dehs.umn.edu/hwd/guidebook/appendix1.html).

(2) Type in either the chemical's name or CAS (Chemical Abstract Services) number and click on "Search." Typing the first few letters of the name will return matches from which you can choose.

(3) If the DDC indicates that the substance is nonhazardous ("xxNH") then the substance generally can be disposed down the sewer or in the trash, but first consult with the stockroom manager or CHO.

(4) **If the DDC includes anything except the "xxNH" designation, then the waste is hazardous waste.**

(5) If your waste is a mixture of chemicals, and if at least one of the original chemicals does not contain the "xxNH" designation, then the combined substance is considered to be hazardous waste.

(6) Inform the CHO or stockroom manager, who will then make the proper final determination and instruct you on the proper steps to follow in Section 12.5.

13.5 HOW TO COLLECT AND LABEL YOUR HAZARDOUS WASTES

13.5.a Identify the Unneeded/Waste Substance as One of the Following Categories.

(1) **Pure Chemical.** Chemicals that were purchased from scientific companies such as Sigma/Flinn/Etc., that are still in the original container or in a properly labeled container.
(2) **Chemical Mixture.** Wastes from experiments, courses; also old solutions, etc.
(3) **Commercial Product.** Products such as indicator dyes, old paints, aerosols, art supplies, photographic chemicals, herbicides, pesticides, etc.
(4) **Unknown Substance.** Anything (such as a Chemical Mixture) for which there is incomplete knowledge in terms of its hazard characteristics (see Section 12.5.d).

13.5.b Inform the Stockroom Manager

(1) The stockroom manager will see if another faculty member has a use for the chemical.

13.5.c For Pure Chemicals or a Commercial Product:

(1) The stockroom manager will print a self-stick label that contains a unique "Container ID Number."
  (a) The jar will be entered into the Waste Disposal Database and placed in the proper storage area within the RNS Chemical Storage Facility to await pick-up by the CSDP. These chemicals will be segregated in the Storage Facility by the DDC.
  (b) Proper waste manifests will be generated by the stockroom manger or CHO
(2) If the original label has been damaged, or if the substance is not in an original container, then you must provide the following information to the stockroom manager:
  (a) For Pure Chemicals: substance name, manufacturer & contact info, concentration, hazards, CAS.
  (b) For Commercial Chemicals: manufacturer & contact info, hazards, the name & CAS for each active ingredient, approximate age, pH (if liquid), MSDS, and description of the product's usage.

13.5.d For Unknowns:

(1) Obtain the "Procedures for Unknowns" worksheet from the stockroom manager and perform as many steps as feasible.
(2) Give the worksheet to the stockroom manager, who will then collect the container.
  (a) The substance will be handled as an unknown or "limited known" and labeled accordingly.
  (b) Disposal costs may be higher than if we had a complete list of ingredients, so faculty are encouraged to always keep track of their containers and eliminate the production of "unknowns."

13.5.e For Chemical Mixtures

(NOTE: Steps 1-3 must be completed BEFORE you start accumulating waste in the container):

(1) Tell the stockroom manager what you plan to pour into the container (you may be required to separate the wastes into two or more containers). Do not proceed until you get the OK from the stockroom manager.
(2) Obtain the following three self-stick labels from the stockroom manager and affix them to the front of the container:
  (a) "Container ID Number" label. This label will also have the start date and room number.
  (b) "Hazardous Waste" label.
  (c) "NPFA" label (if appropriate) that has been properly filled out.
(3) Obtain a "Hazardous Waste Log" sheet from the stockroom manager. This log sheet will also have the "Container ID Number" so that it can be tracked with the appropriate waste container.

(NOTE: Steps 4-6 must be followed while waste is being added to the container):

(4) Keep Container Closed. The container must remain closed at all times, except for those very brief seconds when waste is actually being poured into the container. Leaving the container open during a (for example) 10 minute period is unacceptable and a violation of EPA regulations.
  (a) If the container has a screw-on funnel with a close-top lid, then close the lid.
  (b) If you use a basic removable funnel, then you must remove the funnel and screw on the cap.
(5) Neutralize the Substances – It Saves Us Money. Corrosive wastes are substantially more expensive than the neutralized version of the same wastes. In fact, once neutralization has been completed, the substance may not qualify as waste and it might be permissible to pour it down the sink.
  (a) Neutralize before pouring it into the waste container, or

(b) Neutralize the collected mixture in the container on a set interval (e.g., at the end of each lab period, or after adding *x*-amount of waste to the container). Be alert to the generation of heat.

(6) Enter the Following Info on the Hazardous Waste Log Sheet. Each and every time that a chemical/substance is poured into the waste container, you MUST print the following information onto the Hazardous Waste Log sheet:

(a) Chemical name (complete spelling, **no abbreviations**)

(b) Quantity added (in ml or mg)

(c) Your initials (your students must initialize if they pour substances into containers).

(d) The lab section (if this is for a lab course)

(e) For teaching labs, the HW Log is kept on a clipboard and hung next to the fume hood that is being used to collect the hazardous waste.

(f) Note the presence of any sludge or precipitate.

(NOTE: Steps 7-11 will be completed by stockroom personnel):

(7) Record the final container pH on the Hazardous Waste Log sheet.

(8) Enter the data from the Hazardous Waste Log sheet into the FileMaker Chemical Waste database. Note the presence of any sludge of precipitate.

(9) Print the Hazardous Waste Manifest, give to the CHO.

(10) Print a new self-stick "Hazardous Waste" label and affix it to the front of the container (place it over the original "Hazardous Waste" label). This new label will have a list of all the chemicals that are in the waste container, the percentage (in volume) of each chemical, the total quantity inside the container, the final pH, and the stop date.

13.6 How to Segregate Your Containers of Hazardous Wastes

For compliance with federal and state regulations, and safety considerations of the college community, waste containers held for disposal or that are actively being filled must be properly segregated by chemical hazard class.

13.6.a Use the DDC (http://www.dehs.umn.edu/hwd/guidebook/appendix1.html)

(1) The chemical hazard class is denoted in the first two digits of the DDC.

(2) Only containers that possess the same general hazard class (e.g., combustible/flammables) can be stored together in the same secondary containment tray.

(3) Containers of incompatible chemicals must be physically segregated and cannot be placed in the same secondary containment tray. See Table 9 for examples of incompatible chemicals.

(4) The following substances must be isolated from other substances:

(a) Concentrated nitric acid, which must not be placed in the same secondary containment trays as other acids.

(b) Oxidizers cannot be placed in the same cabinets as flammables.

(c) Containers of Chemical Mixtures are to be segregated by their primary hazard class.

(d) Water sensitive ("xxWS") or shock sensitive ("xxSS") wastes (these must also be further segregated by hazard class).

(5) Below is a list of DDC codes that will indicate which chemicals can be placed in the same secondary containment tray.

Toxic	Caustic	Acid Inorganic	Acid Organic	Flammables	Peroxides	Oxidizers	Bulkables	OK Together	Store Each DDC by Itself
18LI	01LI	02LI	02LO	08LO	08PF	16LI	05BS	02TW	09PL
18LO	01LO	02SI	02SO	08FB	12LO	16LI	06BS	02WS	09SC
18SI	01SI	02HM	02FL	08HM	12SO	16SO	08BS		09WS
18SO	01SO			08CC		16HM	18BS		18CN
05SI	01FL	NA		08WS					18PH
05LI		(=Nitric Acid;		08TW					18TW
05LO		store alone)		06LO					18WS
05SO				09FS					
18HM									
05HM									

01 Corrosive Bases
02 Corrosive Acids
03 ORM-A (Other Regulated Materials-A)
05 ORM-A (Other Regulated Materials-A)
06 Combustibles
07 Flammable Gases
08 Flammable Liquids
09 Flammable Solids
11 Non- Flammable Gases
12 Organic Peroxides
14 Explosives
16 Oxidizers
18 Poisons

NH NonHazardous – dispose in regular sewage or trash
BS Bulkable Solvent
CG Compressed Gas
CL Chlorinated Organic Liquid
CN Cyanide
CS Chlorinated Organic Solid
DX Dioxin Containing
EX Explosive
FB Fuel Blending
HM Heavy Metal
FL Flammable Liquid
HP Pesticide
LI Liquid Inorganic
LO Liquid Organic
NA Nitric Acid
PA Poison A
PB Poison B
PI Poisonous Inorganic
PF Peroxide Former
PO Pourable Oil
FS Flammable Solid
PX PCB Contaminated
RX Radioactive Material
SC Sulfuric/Chromerge
SI Solid Inorganic
SO Solid Organic
SS Shock Sensitive
TS Trade Waste Incinerator
WS Water Sensitive

13.7 MOST COMMON REGULATORY VIOLATIONS

The following are the most commonly cited violations by government inspectors. Laboratory Supervisors are responsible for compliance within their laboratory. Monetary fines levied by government inspectors will generally be the responsibility of the offending department (which may choose to collect funds from a Supervisor's grant, etc.).

13.7.a Improper Labeling. Active waste containers must have:

(1) The words "Hazardous Waste" on them.
(2) The room number, start date, and your initials.
(3) Appropriate NFPA codes.
(4) A data sheet with the name & quantity of every chemical that is poured into the container.

13.7.b Incompatible Wastes/Chemicals Stored Together.

(1) Separate waste containers and reagent chemicals by the first two digits of the drum designation codes (DDC number)

13.7.c Waste Not Contained Properly.

(1) Containers of liquid waste need secondary containment. Bottles of waste should be kept in chemical storage cabinets or in chemically resistant trays

13.7.d Lab Personnel Not Aware of proper handling of hazardous waste, or proper response in event of chemical spill, fire, explosion, or injury.

(1) Train your employees and students in emergency procedures.

13.7.e Chemicals Disposed Improperly.

(1) Do not sewer chemicals without approval of the CHO or Stockroom Manager.
(2) Assuming no additional hazardous characteristics, liquids MUST be neutralized (pH between 5-9) before being sewered.
(3) Do not evaporate residual solvents in fumehoods. Use condensers on all distillation and concentration procedures.
(4) Do not throw hazardous waste in trash.

13.7.f Containers Not Closed.

(1) Containers must be closed except for those brief seconds when adding or removing wastes.

13.7.g Waste Not Compatible with Hazardous Waste Storage Container.

(1) If you have any questions ASK FIRST

13.7.h Hazardous Waste Storage Areas Not Inspected on Weekly Basis.

(1) All hazardous waste containers stored in area not under direct observation of a lab employee, such as in a central chemical storeroom, must be inspected weekly, and the inspections must be documented.
(2) Inspection forms must list dates of inspection, name of person performing inspection, deficiencies in labeling, storage compatibility, secondary containment, any spills and date when deficiency is corrected.

CHAPTER 14

"Employee Information & Training"

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

29 CFR 1910.1450(f)(1)

"Such information shall be presented at the time of the employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations."

29 CFR 1910.1450(f)(2)

"Training to update the information required to be provided under this subdivision shall be repeated at intervals no greater than one year."

Minnesota Statutes 182.653 Subd.4b(j)

14.0 INTRODUCTION

All laboratory personnel who work with or in areas that contain hazardous chemicals are provided with appropriate information and training to ensure that they are apprised of the hazards of the chemicals present in their work area. This chapter outlines the required elements of the information and training sessions, as per the Laboratory Standard and the MERTKA.

14.1 FREQUENCY OF TRAINING

14.1.a Initial Employment or Change in Assignment. This information and training is presented at the time of the employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations.

14.1.b Annual Refresher. All faculty and staff must complete an annual refresher session.

14.1.c Student Workers. Laboratory TAs, RAs, and Stockroom Assistants are employees of the college. They will receive training at the beginning of their Sept-May work period, and again if they work during the summer months.

14.1.d Undergraduates Employed as Summer Researchers. Undergraduate students who are paid to do research on campus during the summer months will receive training at the beginning of their summer employment, generally during the week following Memorial Day.

14.1.e Undergraduates Conducting Independent Research/Studies. Undergraduate students who are conducting research under the guidance of a faculty member must receive training before beginning their project.

14.2 EMPLOYEE INFORMATION AND TRAINING TOPICS

14.2.a Information. Employees shall be informed of (29 CFR 1910.1450(f)(3)):

(1) The contents of the Laboratory Standard and its appendices, which shall be made available to employees.
   (a) The Laboratory Standard is reproduced in Appendix B of this manual.
   (b) The Laboratory Standard can be viewed online at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10106&p_table=STANDARDS

(2) The location and contents of the Chemical Hygiene Plan.
   (a) A hard copy of the CHP is located in the RNS 341 Stockroom, the CHO Office (RNS 312), and online at http://www.stolaf.edu/services/chemical-hygiene.

(3) The Permissible Exposure Limits (PELs) for OSHA-regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard.
   (a) See Section 5.4 of the CHP.

(4) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory.
   (a) See Sections 5.6a(3), 5.9.b, and 5.12.a of the CHP.

(5) 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.
   (a) See Sections 4.2; Sections 5.3-5.11; and 7.2 of the CHP.

14.2.b Training Topics. Employee training shall include (29 CFR 1910.1450(f)(4)):

(1) 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.).

(2) How to recognize and evaluate the physical and health hazards of chemicals and procedures in the work area.

(3) The measures laboratory workers can take to protect themselves from these hazards, including (laboratory) specific procedures the employer has implemented to control exposure to hazardous chemicals, such as:
   (a) How to recognize and evaluate hazards
   (b) How to determine and follow the permissible exposure limits
   (c) Personal protective equipment to be used
   (d) Appropriate work practices
   (e) Spill and emergency procedures (see Chapter 15)
(4) The proper handling and disposal of wastes (see Chapter 10).
(5) Conditions when individuals must seek Prior Approval before working with certain substances/procedures (Section 7.1(i)).
(6) All applicable details of the College's Chemical Hygiene Plan.

14.3 TRAINING RESPONSIBILITIES OF THE CHO AND LAB SUPERVISORS

14.3.a Responsibilities of the CHO

(1) **Conduct Sessions for Laboratory Supervisors and other Faculty/Staff.** The CHO will provide the information and training sessions discussed in Section 14.1.a and 14.1.a. These sessions will cover:
   (a) An overview of the Laboratory Standard and other relevant regulations.
   (b) The contents of the CHP and discussion of its rules and regulations.
   (c) A discussion of the topics on which the Laboratory Supervisors must inform and train their laboratory workers.
(2) **Conduct General Sessions for Lab TA's and Stockroom Workers.** The CHO will provide the general information and training sessions discussed in Section 14.1.c – e. These sessions will include:
   (a) An overview of the Laboratory Standard and other relevant regulations.
   (b) A discussion of the CHP and its required safety policies, with a strong emphasis on Chapters 1, 2, 4-13.

14.3.b Responsibilities of the Laboratory Supervisors

(3) **Provide Lab-Specific Training for Your TAs, Research/Technical Staff, Stockroom Workers, and Undergraduate Student Researchers.**
   (a) Since each course and research laboratory uses its own unique combination of chemicals and operating procedures, *each Laboratory Supervisor is responsible for providing laboratory-specific information and training for their workers, as well as hands-on training for the basic safety rules and procedures in Chapters 4-13 of the CHP*.
   (b) This training will include all information and topics discussed in Sections 14.2a and 14.2b.
   (c) This training will occur at the start of every academic year or as soon as the individual is scheduled to begin his/her project, and ASAP after Memorial Day if the individual works during the summer months.
   (g) Ensure that all laboratory-specific SOP's are written down and posted as needed.

CHAPTER 15

"Handling Emergencies, Injuries and Spills"

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

29 CFR 1910.1450(b)

15.0 Be Prepared

15.0.a Safety Equipment. All laboratory workers must know the locations of (and how to operate) the following safety items: safety showers & eyewashes, fire extinguishers, and spill control equipment.

15.0.b Reporting an Emergency. All laboratory workers must know how to report a fire, injury, chemical spill, or other emergency to summon emergency response, and know the location of the nearest available exit. Instructions and emergency numbers are posted in each lab and by the Stockroom and Departmental telephones.

15.1 Follow the Appropriate Response Guidelines

15.1.a Follow Appropriate Response Guidelines. For serious injuries do not try to take care of the victim by yourself while also calling the paramedics.

(1) If medical help is needed then provide a copy of the appropriate MSDS to the attending physician.

15.1.a Medical Management Guidelines (MMGs) for Acute Chemical Exposures.
(http://www.atsdr.cdc.gov/MMG/index.asp)

(1) As explained on the website, the MMGs were developed by the Agency for Toxic Substances & Disease Registry (U.S. Dept. Health & Human Services) "to aid emergency department physicians and other emergency healthcare professionals who manage acute exposures resulting from chemical incidents. The MMGs are intended to aid healthcare professionals involved in emergency response to effectively decontaminate patients, protect themselves and others from contamination, communicate with other involved personnel, efficiently transport patients to a medical facility, and provide competent medical evaluation and treatment to exposed persons"

(2) Although lab employees are not normally trained as emergency healthcare professionals, the laboratory supervisor is still strongly encouraged to provide the appropriate MMG to all lab workers, and ensure that the lab workers are familiar with all relevant parts of the MMG, including …..

15.1 TREATING INJURIES

15.1.a Get Help. For serious injuries do not try to take care of the victim by yourself while also calling the paramedics.

(1) If medical help is needed then provide a copy of the appropriate MSDS to the attending physician.

(2) As per 29 CFR 1910.1450 Appendix A Sect. 5, personnel trained in first aid are available during working hours, and the Northfield Hospital Emergency Room is located just minutes away.

15.1.b Stay with the Victim. For incidents when paramedics are called, have someone stay with the victim at all times. Keep the victim reassured and watch for signs of shock.

15.1.c Cuts

(1) **Minor Cuts**.

(a) If the injured person has experienced a minor cut, flush the wound with tepid running water to remove any possible chemical contaminants.

(b) For a cut on a gloved hand:

(i) If you do not suspect that the cut has been injected with chemicals, do not immediately remove the glove. First rinse off the glove to avoid contamination of the cut with chemicals

(ii) If you do suspect that the cut has been injected with chemicals, then immediately remove the glove and flush the wound with tepid water.

(c) Apply a sterile bandage and advise the victim that he or she should report any signs of infection to a physician.

(d) If there is a possibility that the wound is contaminated by broken glass or chemicals, the victim should seek immediate medical attention.

(2) **Severe Cuts**.

(a) If the injured person has experienced a more serious injury (if sutures might be necessary) call 9-911 and apply sterile gauze pads to the wound.
(b) If necessary, apply direct pressure to the wound to stop the bleeding.
(c) Apply additional pads if the blood soaks through the first sterile pad. Do not remove the original pads.
(d) If you are unable to stop the bleeding, remain calm and carefully explain the situation to the dispatcher at 9-911. The dispatcher will advise you on further action.

15.1.d Thermal Burn

(1) **No Ointments**. Do not apply ointments or ice to the wound.
(2) **First Degree Burns**. For first degree wounds, flush with copious amounts of tepid running water. Apply a moist dressing and bandage loosely.
(3) **Second or Third Degree Burns**. For second degree (with open blisters) and third degree burns, do not flush with water. Apply a dry dressing and bandage loosely. Immediately seek medical attention.

15.1.e Chemical Splashes & Burns – seek medical help immediately

(1) **Immediately flush the affected area with tepid running water for 15 minutes.** Chemical splashes of strong corrosives can result in chemical burns and are to be treated with the utmost concern and speed. Do not wait for symptoms (such as pain) to develop. Call for paramedics or (for lesser injuries) drive the victim to the Northfield Hospital Emergency Room.
   (a) **Use the sink faucet if:** a hand or only a portion of the lower arm is affected.
   (b) **Use the drench hose or safety shower if:** a larger proportion of an arm is affected, or if a foot or perhaps the lower part of a leg is affected.
   (c) **Use the safety shower if:** an extensive part of an arm or leg or any part of the torso is affected.
   (d) **Use the eyewash if:** you even *suspect* that chemicals may have come in contact with an eye, face, or head. Watch the victim. You may need to help hold the victim's head close to the eyewash, and may even need to use your fingers to hold the eyelids open so that water can thoroughly rinse the eye socket.
(2) **Remove all affected clothing.** Now is not the time for shyness. While drenching the person with water help him/her remove the affected pieces of clothing. Have all others leave the room except for perhaps 1-2 people who can stay behind to hold fire blankets up to allow the victim some additional privacy while they continue to be flushed with water. In addition to removing all contaminated clothing & shoes, remove any jewelry so that the chemical cannot sit against the skin and do further damage.
(3) **No Ointments.** Do not apply ointments, baking soda, ice, or gauze coverings to the wound.
(4) **Hydrofluoric Acid (HF) – seek medical help immediately**
   (a) WARNING: Hydrofluoric acid is an extremely corrosive liquid that can cause severe injury because it readily penetrates the skin and causes decalcification of the bones. Contact with HF can come via skin and eye contact, inhalation, and ingestion.
   (b) **Laboratory workers who are using HF MUST be trained with first-aid procedures for HF exposure before beginning work with HF.**
   (c) Calcium gluconate gel (2.5% w/w) must be present and readily accessible in work areas where any potential HF exposure exists.
   (d) **If Contact with HF occurs,** first-aid must be started within seconds and 9-911 must be called immediately. If the vapor is inhaled, immediately move the victim to fresh air.
      (1) Immediately flush the exposed area with tepid water, remove all contaminated clothing, and call 9-911.
      (2) Apply the calcium gluconate gel after 5 minutes of flushing with water.
      (3) If you are helping the victim do not allow the HF to touch your body!!
(4) **Bromine – seek medical help immediately**
   (a) Flush with running water
   (b) Apply a compress saturated with a dilute sodium thiosulfate solution.

15.1.f Cold Burns – seek medical help immediately. Tissue contact with cryogenic liquids produces damage similar to that associated with thermal burns and can cause severe deep-freezing with extensive destruction of tissue.

(1) Flush affected areas with large volumes of tepid water to reduce freezing. DO NOT APPLY HEAT.

(2) If it is not in the area involved, loosen any clothing that may restrict circulation.
(3) Cover the affected area with a sterile protective dressing or with clean sheets if the area is large, and protect the area from further injury.
(4) Note that frozen tissues are painless and appear waxy with a pallid yellow color. Tissues become painful and edematous upon thawing and the pale color turns to pink or red as circulation of blood is restored.
(5) Tissues that have been frozen show severe, widespread cellular injury and are highly susceptible to infections and additional trauma. Therefore, rapid re-warming of tissues in the field is not recommended if transportation to a medical facility will be delayed.
(6) If Body Temperature has Dropped: If the body temperature is depressed, the patient must be warmed gradually. Shock may occur during the correction of hypothermia. Cardiac dysrhythmias may be associated with severe hypothermia.

15.1.g Ingestion – seek medical help immediately

(1) DO NOT WASTE TIME. Immediately call 9-911 and the Poison Control Center at 9-1-800-764-7661, and consult the MSDS for the appropriate action.
(2) Do not encourage vomiting except under the advice of a physician.
(3) Save all chemical containers and a small amount of vomitus, if possible, for analysis.

15.1.h Unconsciousness or Convulsions

(1) Call 9-911.
(2) If it is safe for you to enter the area:
   (a) **If the victim is unconscious:** Place the victim on his or her back and cover the torso and extremities with a blanket. Do not attempt to remove the victim from the area unless there exists an immediate danger. Clear the area of any chemical spill or broken glassware.
   (b) **If the victim is convulsing:** Remove anything that might cause harm to the victim. Try to protect the victim from further danger with as little interference as possible. Clear the area of any chemical spills or broken glassware.
(3) If the victim begins to vomit, turn the head so that the stomach contents are not aspirated into the lungs.

15.1.i CPR & First Aid. This training (conducted by a Red Cross certified instructor) is encouraged and available for all laboratory workers and is offered free. Contact the CHO to set up a time to receive training.

15.1.j Incident Report Forms. After each incident an incident report form must be submitted to the CHO. Ideally this form will be filled out by the victim and the St. Olaf person who helped.

15.2 CHEMICAL SPILLS – WHAT TO DO

St. Olaf science personnel take pride in being careful while handling chemicals; however, all laboratory workers must be prepared for accidentals spills. Small spills can be safely and adequately cleaned up using the spills kits that are distributed throughout the laboratories. In the event of an accidental chemical release or spill of a larger quantity (e.g., if a 4L jar breaks), personnel should refer to the following general guidelines. Consult the CHO or Laboratory Stockroom Managers if you have any questions regarding the following guidelines.

15.2.a Be Prepared and Respond Accordingly. Laboratory personnel must be familiar with the chemical, physical, and toxicological properties of every hazardous substance in their laboratory.

(1) Consult the label and the Material Safety Data Sheet prior to the initial use of each hazardous substance. Know what to do in case of a spill.
(2) Personal protective equipment should be used that is appropriate to the degree of hazard of the chemical in use.
(3) Decontaminate any victims with the nearest safety shower, eyewash, or other appropriate action as described in the Material Safety Data Sheet. Check to be sure that the chemical did not get on anyone.
(4) Alert all other workers in the laboratory and the general vicinity of the spill. Immediately inform the CHO and Department Chair.

(5) Dispose of contaminated materials according to departmental policy (i.e., if the original chemical was hazardous then the chemical-soaked absorbent must be disposed as hazardous waste).

(6) **For large/severe spills** (e.g., a 4 liter jar of concentrated Nitric Acid):

(a) **Call for Help!** Get the Stockroom Manager. Call Public Safety (3666) and 9-911 if necessary.

(b) **Evacuate & (if possible) remove affected persons; tend to any injured persons.**

(c) **Close doors/confine the area.** Alert people in neighboring labs, offices, or public spaces.

(d) **Secure the area.**

(e) **Report the spill to the CHO** (if the CHO isn't already on the scene).

15.2.b Low Flammability and Low Toxicity Materials that are not Volatile (e.g., bases and inorganic acids)

(1) Wear personal protective equipment that is appropriate to the degree of hazard of the spilled substance.

(2) Using the chemical spill kits that contain an inert absorbent, clean up the affected area if this action can be accomplished without risk of additional injury or contamination to personnel. If the spill is located on the laboratory floor, be aware that some absorbents can create a slipping hazard.

15.2.c Flammable Solvents of Low Toxicity (e.g., diethyl ether and tetrahydrofuran)

(1) Extinguish all flames and turn off any spark-producing equipment. If necessary, turn off the power to the laboratory at the circuit breaker (except the ventilation system must remain operational).

(2) Wear personal protective equipment that is appropriate to the degree of hazard of the spilled substance.

(3) Using spill pillows or spill absorbent and non-sparking tools, soak up the solvent as quickly as possible. Be sure to soak up chemicals that have seeped under equipment and other objects in the laboratory. If the spill is located on the laboratory floor, be aware that some absorbents can create a slipping hazard.

15.2.d Highly Toxic Materials (e.g., dimethylmercury and hydrofluoric acid)

(1) DANGER!! Alert all other workers in the laboratory and the general vicinity of the spill and immediately evacuate the area.

(2) Inform the CHO and Stockroom Manager. Do not attempt to clean up the spill. They will evaluate the hazards that are involved with the spill and will take the appropriate actions. Outside industrial hygienists may be the only persons authorized to decontaminate the area and dispose of the contaminated waste.

CHAPTER 16

"Medical Consultation & Examinations"

16.0 INTRODUCTION

All employees working with hazardous chemicals have the right to receive medical attention and any follow-up examinations deemed necessary by the examining physician under the conditions listed in Section 17.1.

16.1 PROVISIONS FOR MEDICAL CONSULTATION AND EXAMINATION (29 CFR 1910.1450(g))

17.1.a Opportunity to Receive Medical Attention. The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

(1) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
(2) Where exposure monitoring reveals an exposure level routinely above the PEL or action level, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
(3) Whenever an event takes place in the work area such as a spill or leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure.

16.1.b Medical Surveillance. Whenever college-required work involves regular and frequent handling of toxicologically significant quantities of a chemical, the employee should consult (at no cost to the employee) a physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable.

16.1.c Medical Examinations. All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician, and shall be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

16.1.d Information Provided to the Physician. The employer shall provide the following information to the physician:

(1) The identity of the hazardous chemical(s) to which the employee may have been exposed.
(2) A description of the conditions under which the exposure occurred including quantitative exposure data, if available.
(3) A description of the signs and symptoms of exposure the employee is experiencing, if any.

16.1.e Physician's written opinion.

(1) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician that shall include the following:
    (a) Any recommendation for further medical follow-up.
    (b) The results of the examination and any associated tests.
    (c) Any medical condition that may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace.
    (d) A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.
(2) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

CHAPTER 17

"Record Keeping"

17.0 INTRODUCTION

St. Olaf College maintains all appropriate records that relate to chemical health and safety policies and procedures.

17.1 TYPES OF RECORDS

17.1.a Accident Records & Incident Report Form.
17.1.a Training.
17.1.a Lab inspections.
17.1.a HW inspections.
17.1.a SAP inspections.
17.1.a Fume hood inspections.
17.1.a Exposure monitoring & medical records – kept by HR.

APPENDIX A

Tables 1-20

Most of these tables were adopted and modified from the University of Minnesota Department of Chemistry's Chemical Hygiene Plan http://www.chem.umn.edu/safety/safety.html

TABLE 1. Examples of some high-energy oxidizers.

Name	Formula
Ammonium perchlorate	(NH4ClO4)
Ammonium permanganate	(NH4MnO4)
Barium peroxide	(BaO2)
Bromine	(Br)2
Calcium chlorate	(Ca[ClO3]2.2H2O)
Calcium hypochlorite	(Ca[ClO]2)
Chlorine trifluoride	(ClF3)
Chromium anhydride or chromic acid	(CrO3)
Dibenzoyl peroxide	([C6H5CO]2O2)
Fluorine	(F2)
Hydrogen peroxide	(H2O2)
Magnesium perchlorate	(Mg[ClO4]2)
Nitric acid	(HNO3)
Nitrogen peroxide (in equilibrium with nitrogen dioxide)	N2O4; NO2
Nitrogen trioxide	(N2O3)
Perchloric acid	(HClO4)
Potassium bromate	(KBrO3)
Potassium chlorate	(KClO3)
Potassium perchlorate	(KClO4)
Potassium peroxide	(K2O3)
Propyl nitrate (normal)	(CH3 [CH2]2 NO3)
Sodium chlorate	(NaClO3)
Sodium chlorate	(NaClO2)
Sodium perchlorate	(NaC1O4)
Sodium peroxide	(Na2O2)

TABLE 2. Chemicals with low flash points.

The following table lists some of the most common organic chemicals with low flash points (below 32 °C), as measured by the Closed Cup method. These chemicals present a notable fire risk, which must be taken into account when planning work involving them.

Chemical	Flash Point (°C)	Chemical	Flash Point (°C)
Acetaldehyde	-38	Ethyl acetate	-4
Acetone	-18	Ethyl acrylate	16
Acetonitrile	6	Ethyl formate	-20
Acetyl chloride	4	Heptane	-4
Acrylonitrile	0	Hexane	-22
Allyl iodide	<21	Isopropyl alcohol	11.7
Benzene	11	Methyl alcohol	12
Butyl alcohols	24-29		
Carbon disulfide	-30	4-Methylpentan-2-one	17
Chloromethane	<0	Pentane	-49
Cyclohexane	-20	Piperidine	16
1,2-Dichloroethane	13	Propan-2-ol	12
Diethylamine	<-26	Pyridine	20
Diethyl carbonate	25	Tetrahydrofuran	-17
Diethyl ether	-45	Toluene	4
Dioxan	12	Triethylamine	-7
Ethyl alcohol	13	Vinyl acetate	-8
Ethyl chloroformate	16	p-Xylene	28

TABLE 3. NFPA 45 Storage Limits for Flammable and Combustible Liquids*.

Class of Liquid	Excluding Quantities in Storage Cabinets and Safety Cans		Including Quantities in Storage Cabinets and Safety Cans	
	Maximum Quantity per 100 sq. ft of Lab Unit (Gal)	Maximum Quantity per Lab Unit (Gal)	Maximum Quantity per 100 sq. ft of Lab Unit (Gal)	Maximum Quantity per Lab Unit (Gal)
Class I	2	75	4	150
Class II	4	100	8	200
Class IIIA	4	100	8	200

* In determining the quantity allowed, the more restrictive quantity based on either the lab unit or the quantity per 100 sq. ft of lab unit applies.

TABLE 4. Classes of explosive compounds

Acetylenic compounds	Alkyl or acyl peroxides
Metal acetylides or carbides	Alkyl hydroperoxides
Haloacetylides	Dialkyl peroxycarbonates
Diazo compounds	Metal fulminates, oximates
Nitroso compounds	Transition metal carbonyl compounds
Nitroalokanes, C-nitro and polynitroaryl compounds	Polynitroalkyl compounds, trinitroethyl compounds
Acyl or alkyl nitrates	Metal cyanides, organic nitriles, cyanogen halides
Acyl or alkyl nitrites	Organic azides, acyl azides, metal azides, metal azide complexes

TABLE 5. Some classes of shock sensitive chemicals.

The classes of chemicals listed below may explode when subjected to shock or friction. Therefore users must have appropriate laboratory equipment, information, knowledge, and training to use these compounds safely.

Chemical Group	Especially Sensitive Examples
Acetylenic compounds	Polyacetylenes, haloacetylenes, and heavy metal salts of acetylenes (copper, silver, and mercury salts are particularly sensitive)
Acyl nitrates	
Alkyl nitrates	Polyol nitrates such as nitrocellulose and nitroglycerine
Alkyl and acyl nitrites	
Amminemetal oxosalts	Metal compounds with coordinated and hydrazine, or similar nitrogenous donors and ionic perchlorate, nitrate, permanganate, or other oxidizing group
Azides, including metal, nonmetal, and organic azides	
Chlorite salts of metals	AgClO2 and Hg(ClO2)2
Diazo compounds	CH2N2
Diazonium salts, when dry	
Fulminates	Mercury fulminate (Hg(CNO)2)
Hydrogen peroxide	Which becomes increasingly treacherous as the concentration rises above 30%, forming explosive mixtures with organic materials and decomposing violently in the presence of traces of transition metals
N-Halogen compounds	Difluoroamino compounds and halogen azides
N-Nitro compounds	N-nitromethylamine, nitrourea, nitroguanidine, and nitric amide
Oxo salts of nitrogenous bases	Perchlorates, dichromates, nitrates, iodates, chlorites, chlorates, and permanganates of ammonia, amines, hydroxylamine, guanidine, etc.
Perchlorate salts *	Which can form when perchloric acid mists dry in fume hoods or associated duct work. Most metal, nonmetal, and amine perchlorates can be detonated and may undergo violent reaction in contact with combustible materials
Peroxides and hydroperoxides, organic	
Peroxides (solid)	When crystallizes from or are left from evaporation of peroxidizable solvents (see the following Section 3)
Peroxides, transition-metal salts	
Picrates	Salts of transition and heavy metals, such as Ni, Pb, Hg, Cu, and Zn
Polynitroalkyl compounds	Tetranitromethane and dinitroacetonitrile
Polynitroaromatic compounds	Polynitrohydrocarbons, phenols, and amines (e.g., dinitrotoluene, trinitrotoluene, and picric acid)

* Note: Perchloric acid must be used only in specially-designed perchloric acid fume hoods that have built-in wash down systems to remove shock-sensitive deposits.

TABLE 6. Examples of shock sensitive materials.

The following substances are shock-sensitive, and may decompose violently if struck or heated. Solids are also prone to explosive decomposition if ground, for example with pestle and mortar. A few of the materials listed are not, of themselves, explosive, but mixtures of them with combustible material such as organic reagents, may be dangerous.

Acetylides	Guanyl nitrosamino guanyltetrazene	Nitrourea
Aluminum ophorite explosive	Guanyl nitrosamino guanylidene	Organic nitramines
Amatol	Guanylidene	Organic amine nitrates
Ammonal	Hydrazine	Organic peroxides
Ammonium nitrate	Hydrazoic acid	Picramic acid
Ammonium perchlorate	Heavy metal azide	Picramide
Ammonium picrate	Hexanite	Picric acid
Butyl tetryl	Hexanitrodiphenylamine	Picryl chloride
Calcium nitrate	Hexanitrostilbene	Picryl fluoride
Copper acetylide	Hexogen	Potassium nitroaminotetrazole
Cyanuric triazide	Hyrazinium nitrate	Robenzoic acid
Cyclotrimethylenetrinitramine	Lead azide, mononitroresorcinate, mannite, picrate, styphnate	Silver acetylide, azide, fulminate, styphnate, tetrazene
Dinitroethyleneurea	Magnesium ophorite	Sodatol
Dinitroglycerine	Mannitol hexanitrate	Sodium amatol, dinitro-ortho-cresolate, picramate,
Dinitrophenol	Mercury oxalate, fulminate, tartrate	Syphnic acid
Dinitrophenolates	Nitrated carbohydrate	Tetranitrocarbazole
Dinitrophenyl hydrazine	Nitrated glucoside	Tetraze
Dinitrotoluene	Nitrogen triiodide, trichloride	Tetrytol
Dipicrylamine	Nitroglycerin	Trinitroanisole
Dipicryl sulfone	Nitroglycide	Trinitrobenzene
Erythritol tetranitrate	Nitroglycol	Trimonite
Fulminate of silver	Nitroguanidine	Trinitronaphthalene
Fulminating gold	Nitronium perchlorate	Trinitrophenetol
Fulminating platinum	Nitroparaffins	Trinitrotoluene
Gelatinized nitrocellulose	Nitrotoluene	Urea nitrate

TABLE 7. Examples of peroxide-forming chemicals.

Chemicals that form potentially explosive peroxides without concentration
(Discard within 3 months from opening)

Organics	Inorganics
Divinyl ether	Potassium amide
Divinyl acetylene (DVA)	Potassium metal
Isopropyl ether (diisopropyl ether)	Sodium amide (sodamide)
Vinylidene chloride (1,1-dichloroethylene)	

Chemicals that form potentially explosive peroxides on concentration
(Discard or test for peroxides within 3 months from opening)

Acetal (acetaldehyde diethyl acetal)	Ethylene glycol monoether
Acetaldehyde	Furan
Benzyl alcohol	4-Heptanol
2-Butanol	Methyl acetylene
Cumene ((isopropylbenzene)	Methy isobutyl ketone
Cyclohexene	3-Methyl-1-butanol
Cyclohexanol	Methyl cyclopentane
2-Cyclohexen-1-ol	2-Pentanol
Cyclopentene	4-Pentene-1-ol
Decahydronaphthalene (decalin)	1-Phenylethanol
Dicyclopentadiene	2-Phenylethanol
Diethyl ether (ether)	2-Propanol (isopropanol, IPA)
Diethylene glycol dimethyl ether (Diglyme)	Tetrahydrofuran
Dioxane	Tetrahydronaphthalene (tetralin)
Ethylene glycol dimethyl ether (Glyme)	Vinyl ethers
Ethylene glycol ether acetates	Other secondary alcohols

Chemicals that autopolymerize
(Discard or test for peroxides within 3 months from opening)

Acrylic acid	Styrene
Acrylonitrile	Tetrafluoroethylene
Butadiene (Diacetylene)	Vinyl acetate
Chloroprene (2-chloro-1,3 butadiene)	Vinyl acetylene
Chrolorotrifluoroehtylene	Vinyl chloride
Methyl methacrylate	Vinyl pyridine

TABLE 8. Examples of incompatible chemicals.
A wide variety of chemicals react dangerously when mixed with certain other materials. Some of the more widely-used incompatible chemicals are given below, but the absence of a chemical from this list should not be taken to indicate that it is safe to mix.

Chemical:	Incompatible with:
Acetic acid:	Chromic acid, ethylene glycol, nitric acid, hydroxyl compounds, perchloric acid, peroxides, permanganates
Acetone:	Concentrated sulphuric and nitric acid mixtures
Acetylene:	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali and alkaline earth metals:	Water, chlorinated hydrocarbons, carbon dioxide, halogens, alcohols, aldehydes, ketones, acids
Aluminium (powdered):	Chlorinated hydrocarbons, halogens, carbon dioxide, organic acids.
Anhydrous ammonia:	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium nitrate:	Acids, metal powders, flammable liquids, chlorates, nitrites, sulphur, finely divided organic combustible materials
Aniline:	Nitric acid, hydrogen peroxide
Arsenic compounds:	Reducing agents
Azides:	Acids
Bromine:	Ammonia, acetylene, butadiene, hydrocarbons, hydrogen, sodium, finely-divided metals, turpentine, other hydrocarbons
Calcium carbide:	Water, alcohol
Calcium oxide:	Water
Carbon, activated:	Calcium hypochlorite, oxidizing agents
Chlorates:	Ammonium salts, acids, metal powders, sulphur, finely divided organic or combustible materials
Chromic acid:	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohols, flammable liquids in general
Chlorine:	See bromine
Chlorine dioxide:	Ammonia, methane, phosphine, hydrogen sulfide
Copper:	Acetylene, hydrogen peroxide
Cumene hydroperoxide:	Acids, organic or inorganic
Chlorine:	See bromine
Chlorine dioxide:	Ammonia, methane, phosphine, hydrogen sulfide
Copper:	Acetylene, hydrogen peroxide
Cumene hydroperoxide:	Acids, organic or inorganic
Cyanides:	acids
Flammable liquids:	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens

Hydrocarbons:	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid:	Nitric acid, alkali
Hydrofluoric acid:	Aqueous or anhydrous ammonia
Hydrogen peroxide:	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases
Hydrogen sulphide:	Fuming nitric acid, oxidizing gases
Hypochlorites:	Acids, activated carbon
Iodine:	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury:	Acetylene, fulminic acid, ammonia
Mercuric oxide:	Sulphur
Nitrates:	Sulphuric acid
Nitric acid (conc.):	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulphide, flammable liquids, flammable gases
Oxalic acid:	Silver, mercury
Perchloric acid:	Acetic anhydride, bismuth and its alloys, ethanol, paper, wood
Peroxides (organic):	Acids, avoid friction or shock
Phosphorus (white):	Air, alkalies, reducing agents, oxygen
Potassium:	Carbon tetrachloride, carbon dioxide, water, alcohols, acids
Potassium chlorate:	Acids
Potassium perchlorate:	Acids
Potassium permanganate:	Glycerin, ethylene glycol, benzaldehyde, sulphuric acid
Selenides:	Reducing agents
Silver:	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium:	Carbon tetrachloride, carbon dioxide, water
Sodium nitrate:	Ammonium salts
Sodium nitrite:	Ammonium salts
Sodium peroxide:	Ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulphide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulphides:	Acids
Sulphuric acid:	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)
Tellurides:	Reducing agents
Zinc powder:	Sulphur

TABLE 9. Related and compatible storage groups.

Inorganic Family	Organic Family
Metals, hydrides	Acids, anhydrides, peracids
Halides, sulfates, sulfites, thiosulfates, phosphates, halogens, acetates	Alcohols, gycols, amines, imines, imides
Amides, nitrates, (except ammonium nitrate), nitrites, azides	Hydrocarbons,esters, aldehydes
Hydroxides, oxides, silicates, carbonates, carbon	Ethers, ketones, ketenes, halogenated hydrocarbons, ethylene oxide
Sulfides, selenides, phosphides, carbides, nitrides	Epoxy compounds, isocyanates
Chlorates, perchlorates, perchloric acid, chlorites, hypochlorites, peroxides, hydrogen peroxide	Peroxides, hydroperoxides, azides
Arsenates, cyanides, cyanates	Sulfides, polysulfides, sulfoxides, nitrites
Borates, chromates, manganates, permanganates	Phenols, cresols
Acids (*nitric acid must be isolated and stored by itself)	
Sulfur, phophorous, arsenic, phosphorous pentoxide	

TABLE 10. Examples of pyrophoric chemicals

The classes of chemicals listed below will readily oxidize and ignite spontaneously in air. Therefore, users must have the appropriate laboratory equipment, information, knowledge, and training to use these compounds safely.

Chemical Group	Examples
Grignard reagents	RMgX
Metal alkyls and aryls	RLi, RNa, R3Al, R2Zn
Metal carbonyls	Ni(CO)4, Fe(CO)5, Co2(CO)8
Alkali metals	Na, K
Metal powders	Al, Co, Fe, Mg, Mn, Pd, Pt, Ti, Sn, Zn, Zr
Metal hydrides	NaH, LiAlH4
Nonmetal hydrides	B2H6 and other boranes, PH3, AsH3
Nonmetal alkyls	R3B, R3P, R3As
Phosphorus (white)	

TABLE 11. Examples of water-reactive chemicals.

Class of Compound	Examples
Alkali metals	Li, Na, K
Anhydrous metal halides	$AlCl_3$, $AlBr_3$, $TiCl_4$, $ZrCl_4$, $SnCl_4$
Nonmetal halides	BCl_3, BF_3, PCl_3, PCl_5, $SiCl_4$
Nonmetal oxides	SO_3, PO_5
Inorganic acid halides	$POCl_2$, $SOCl_2$, SO_2Cl_2
Metal oxides	CaO

TABLE 12. Examples of common corrosive substances.

Acetic acid	Chromate	Phosphorous pentoxide
Aluminum chloride	Cupric bromide	Potassium
Ammonium dichromate	Hexafluorosilicate	Potassium cyanide
Ammonium oxalate	Hydrochloric acid	Potassium fluoride
Antimony pentachloride	Hydrofluoric acid	Potassium metal
Antimony trichloride	Hydroquinone	Sodium cyanide
Bismuth trichloride	Lithium	Sodium ferrocyanide
Bromine	Nitric acid	Sodium hydroxide
Calcium oxide	Oxalic acid disodium	Stannic chloride
Chlorine	Phosphorous (white)	Sulfuric acid

TABLE 13. Examples of common irritants.

Acetyaldehyde	p-Dichlorobenzene	Methyl methacrylate
Acetic anhydride	Diethyl phthalate	Methyl salicylate
Ammonia	Ethyl methacrylate	Naphthalene
Antimony oxide	Ferric chloride	Phthalic anhydride
Calcium carbide	Hexachlorophene	Potassium permanganate
Calcium fluoride	Hydrogen peroxide	Sodium sulfide
Catechol	Hydrogen sulfide	Sulfuric acid, fuming
Cupric chloride	Iodine (crystals)	Titanium trichloride
Cupric nitrate	Lead carbonate	Toluene
Cupric sulfate	Methyl ethyl ketone	Trichlorotrifluoroethane

TABLE 14. Examples of common sensitizers.

Benzocaine	Hexamethylenediisocyanate	Organomercurials
Chromium salts	Mercaptobenzthiazole	p-Phenylenediamine
Cobalt salts	Methyl methacrylate	p-Tertiary butyl phenol
Diphenylquanidine	Neomycin	Resorcinol monobenzoate
Formaldehyde	Nickel and nickel salts	Thiuram sulfides

TABLE 15. Examples of neurotoxins and toxins that affect target organs.

Type of Toxin	Affected Organ	Signs and Symptoms	Examples
Agents acting on the hematopoietic system	Hemoglobin, deprive the body tissues of oxygen	Cyanosis, loss of consciousness	Carbon monoxide, cyanides
Agents which damage the lung	Pulmonary tissue	Cough, tightness in chest, shortness of breath	Silica, asbestos
Cutaneous hazards	Dermal layer of the body	Defatting of the skin, rashes, irritation	Ketones, chlorinated compounds
Eye hazards	Eye	Conjunctivitis, corneal damage	Organic solvents, acids
Hepatotoxins	Liver	Jaundice, liver enlargement	Carbon tetrachloride, nitrosamines
Nephrotoxins	Kidney	Edema, proteinuria	Halogenated hydrocarbons, uranium
Neurotoxins	Nervous system	Narcosis, behavioral changes, decrease in motor functions	Mercury, carbon disulfide

TABLE 16. Examples of reproductive toxins.

Arsenic and certain arsenic compounds	Lead compounds
Benzene	Mercury compounds
Cadmium and certain cadmium compounds	Toluene
Carbon disulfide	Vinyl chloride
Ethylene glycol	Xylene
Ethylene oxide	

TABLE 17. Examples of acutely toxic compounds.

Acrolein	Hydrofluoric acid	Osmium salts
Arsenic compounds	Methyl fluorosulfonat	Ozone
Chlorine	Nickel carbonyl	Phenol
Cyanides	Nitrogen dioxide	Phosgene
Diazomethane	dioxide	

TABLE 18. Examples of Poisonous Gases

The gases on this list are either on the Department of Transportation's Category 1 list, or the Linde Specialty Gases company's Group 6 – Very Poisonous list. These chemicals are highly toxic gases at ambient temperature and pressure. They have an extremely high potential for causing significant harm if not adequately controlled.

Arsine	Germane	Phosphorus pentafluoride
Boron trichloride	Hydrogen selenide	Selenium hexafluoride
Chlorine pentafluoride	Nitric oxide	Stibine
Chlorine trifluoride	Nitrogen dioxide	Sulfur tetrafluoride
Cyanogen	Nitrogen trioxide	Tellurium Hexafluoride
Cyanogen chloride	Nitrosyl chloride	Tetraethyldithiopyrophosphate
Diborane	Oxygen difluoride	Tetraethylpyrophosphate
Dinitrogen tetroxide	Phosgene	
Fluorine	Phosphine	

TABLE 19. Toxicity ratings and probable lethal dose limits for humans.

Toxicity Rating	Animal LD_{50} (per kg)	Lethal Dose if Ingested by 70-kg (150-lb) Human
Extremely toxic	Less than 5 mg	A taste (less than 7 drops)
Highly toxic	5 to 50 mg	Between 7 drops and 1 teaspoonful
Moderately toxic	50 to 500 mg	Between 1 teaspoonful and 1 ounce
Slightly toxic	500 mg to 5 g	Between 1 ounce and 1 pint
Practically nontoxic	Above 5 g	Above 1 pint

APPENDIX B

29 CFR 1910.1450

"Occupational Exposure to Hazardous Chemicals in Laboratories"

(commonly referred to as the "Laboratory Standard")

1910.1450(a) ***Scope and application.***
1910.1450(a)(1)
This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

1910.1450(a)(2)
Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:
1910.1450(a)(2)(i)
For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.
1910.1450(a)(2)(ii)
Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.
1910.1450(a)(2)(iii)
Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.

1910.1450(a)(3)
This section shall not apply to:
1910.1450(a)(3)(i)
Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.
1910.1450(a)(3)(ii)
Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:
1910.1450(a)(3)(ii)(A)
Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and
1910.1450(a)(3)(ii)(B)
Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

1910.1450(b) ***Definitions—***

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

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

"Carcinogen" (see "select carcinogen").

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

"Chemical Hygiene Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

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

"Compressed gas" means:
(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or
(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg C) regardless of the pressure at 70 deg. F (21.1 deg. C); or
(iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 C) as determined by ASTM D-323-72.

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

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

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

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

"Flammable" means a chemical that falls into one of the following categories:
(i) Aerosol, flammable means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;
(ii) Gas, flammable means:
(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or
(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
(iii) Liquid, flammable means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.
(iv) Solid, flammable means a solid, other than a blasting agent or explosive as defined in § 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:
(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24 - 1979 (ASTM D 56-79)) - for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or
(ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7 - 1979 (ASTM D 93-79)) - for liquids with a viscosity equal to or greater than 45 SUS at 100 deg. F (37.8 deg. C), or that contain suspended solids, or that have a tendency to form a surface film under test; or
(iii) Setaflash Closed Tester (see American National Standard Method of test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)).

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

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

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

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

"Laboratory scale" means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safety manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

"Laboratory-type hood" means a device located in a laboratory, enclosure on five sides with a movable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

"Laboratory use of hazardous chemicals" means handling or use of such chemicals in which all of the following conditions are met:
(i) Chemical manipulations are carried out on a "laboratory scale;"
(ii) Multiple chemical procedures or chemicals are used;
(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and
(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

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

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

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

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

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

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

"Select carcinogen" means any substance which meets one of the following criteria:
(i) It is regulated by OSHA as a carcinogen; or
(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP)(latest edition); or
(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or
(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
(A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3);
(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or
(C) After oral dosages of less than 50 mg/kg of body weight per day.

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

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

1910.1450(c) Permissible exposure limits.

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

1910.1450(d) Employee exposure determination—

1910.1450(d)(1)
Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

1910.1450(d)(2)
Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

1910.1450(d)(3)
Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.

1910.1450(d)(4)
Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

1910.1450(e) Chemical hygiene plan -- General.
(Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan).

1910.1450(e)(1)

Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:
1910.1450(e)(1)(i)
Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and
1910.1450(e)(1)(ii)
Capable of keeping exposures below the limits specified in paragraph (c) of this section.

1910.1450(e)(2)
The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

1910.1450(e)(3)
The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection;
1910.1450(e)(3)(i)
Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;
1910.1450(e)(3)(ii)
Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;
1910.1450(e)(3)(iii)
A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;
1910.1450(e)(3)(iv)
Provisions for employee information and training as prescribed in paragraph (f) of this section;
1910.1450(e)(3)(v)
The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;
1910.1450(e)(3)(vi)
Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;
1910.1450(e)(3)(vii)
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; and
1910.1450(e)(3)(viii)
Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:
1910.1450(e)(3)(viii)(A)
Establishment of a designated area;
1910.1450(e)(3)(viii)(B)
Use of containment devices such as fume hoods or glove boxes;
1910.1450(e)(3)(viii)(C)
Procedures for safe removal of contaminated waste; and
1910.1450(e)(3)(viii)(D)
Decontamination procedures.

1910.1450(e)(4)
The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

1910.1450(f) Employee information and training.

1910.1450(f)(1)

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

1910.1450(f)(2)
Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

1910.1450(f)(3)
Information. Employees shall be informed of:
1910.1450(f)(3)(i)
The contents of this standard and its appendices which shall be made available to employees;
1910.1450(f)(3)(ii)
the location and availability of the employer's Chemical Hygiene Plan;
1910.1450(f)(3)(iii)
The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
1910.1450(f)(3)(iv)
Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and
1910.1450(f)(3)(v)
The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.

1910.1450(f)(4)
Training.
1910.1450(f)(4)(i)
Employee training shall include:
1910.1450(f)(4)(i)(A)
Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
1910.1450(f)(4)(i)(B)
The physical and health hazards of chemicals in the work area; and
1910.1450(f)(4)(i)(C)
The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.
1910.1450(f)(4)(ii)
The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

1910.1450(g) Medical consultation and medical examinations.

1910.1450(g)(1)
The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:
1910.1450(g)(1)(i)
Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
1910.1450(g)(1)(ii)
Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

1910.1450(g)(1)(iii)
Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

1910.1450(g)(2)
All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

1910.1450(g)(3)
Information provided to the physician. The employer shall provide the following information to the physician:
1910.1450(g)(3)(i)
The identity of the hazardous chemical(s) to which the employee may have been exposed;
1910.1450(g)(3)(ii)
A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
1910.1450(g)(3)(iii)
A description of the signs and symptoms of exposure that the employee is experiencing, if any.

1910.1450(g)(4)
Physician's written opinion.
1910.1450(g)(4)(i)
For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:
1910.1450(g)(4)(i)(A)
Any recommendation for further medical follow-up;
1910.1450(g)(4)(i)(B)
The results of the medical examination and any associated tests;
1910.1450(g)(4)(i)(C)
Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace; and
1910.1450(g)(4)(i)(D)
A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.
1910.1450(g)(4)(ii)
The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

1910.1450(h) Hazard identification.

1910.1450(h)(1)
With respect to labels and material safety data sheets:
1910.1450(h)(1)(i)
Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
1910.1450(h)(1)(ii)
Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.
1910.1450(h)(2)
The following provisions shall apply to chemical substances developed in the laboratory:
1910.1450(h)(2)(i)
If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.
1910.1450(h)(2)(ii)

If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.
1910.1450(h)(2)(iii)
If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of material safety data sheets and labeling.

1910.1450(i) Use of respirators.
Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

1910.1450(j) Recordkeeping.

1910.1450(j)(1)
The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

1910.1450(j)(2)
The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.1020.

1910.1450(k) Dates—

1910.1450(k)(1)
Effective date. This section shall become effective May 1, 1990.

1910.1450(k)(2)
Start-up dates.
1910.1450(k)(2)(i)
Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.
1910.1450(k)(2)(ii)
Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

Appendix A to 1910.1450 — National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)

Table of Contents

Foreword

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

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

"Prudent Practices" deal with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical Hygiene" being substituted for the word "safety". However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F.

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

Corresponding Sections of the Standard and this Appendix

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

Paragraph and topic in laboratory standard		Relevant appendix section
(e)(3)(i)	Standard operating procedures for handling toxic chemicals.	C, D, E
(e)(3)(ii)	Criteria to be used for implementation of measures to reduce exposures.	D
(e)(3)(iii)	Fume hood performance	C4b
(e)(3)(iv)	Employee information and training (including emergency procedures).	D10, D9
(e)(3)(v)	Requirements for prior approval of laboratory activities.	E2b, E4b
(e)(3)(vi)	Medical consultation and medical examinations.	D5, E4f
(e)(3)(vii)	Chemical hygiene responsibilities.	B
(e)(3)(viii)	Special precautions for work with particularly hazardous substances.	E2, E3, E4

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

A. General Principles for Work with Laboratory Chemicals

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

1. It is prudent to minimize all chemical exposures. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2,10). Skin contact with chemicals should be avoided as a cardinal rule (198).
2. Avoid underestimation of risk. Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10, 37, 38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).
3. Provide adequate ventilation. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).
4. Institute a chemical hygiene program. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6,11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).
5. Observe the PELs, TLVs. The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded (13).

B. Chemical Hygiene Responsibilities

Responsibility for chemical hygiene rests at all levels (6, 11, 21) including the:
1. Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).
2. Supervisor of the department or other administrative unit, who is responsible for chemical hygiene in that unit (7).
3. chemical hygiene officer(s), whose appointment is essential (7) and who must:
   (a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);
   (b) Monitor procurement, use, and disposal of chemicals used in the lab (8);
   (c) See that appropriate audits are maintained (8);
   (d) Help project directors develop precautions and adequate facilities (10);

(e) Know the current legal requirements concerning regulated substances (50); and
(f) Seek ways to improve the chemical hygiene program (8, 11).

4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:
(a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);
(b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);
(c) Know the current legal requirements concerning regulated substances (50, 231);
(d) Determine the required levels of protective apparel and equipment (156, 160, 162); and
(e) Ensure that facilities and training for use of any material being ordered are adequate (215).

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

6. Laboratory worker, who is responsible for:
(a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7, 21, 22, 230); and
(b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

1. Design. The laboratory facility should have:
(a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);
(b) Adequate, well-ventilated stockrooms/storerooms (218, 219).
(c) Laboratory hoods and sinks (12, 162);
(d) Other safety equipment including eyewash fountains and drench showers (162, 169); and
(e) Arrangements for waste disposal (12, 240).

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

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

4. Ventilation –
(a) General laboratory ventilation. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).
(b) Hoods. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.
(c) Other local ventilation devices. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).
(d) Special ventilation areas. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).
(e) Modifications. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).
(f) Performance. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).
(g) Quality. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfm) (200, 204).
(h) Evaluation. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made

(12, 195, 207). See pp 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures (Recommendations for these are given in section E, below)
2. Chemical Procurement, Distribution, and Storage
   (a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).
   (b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19).
   Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).
   (c) Distribution. When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).
   (d) Laboratory storage. Amounts permitted should be as small as practical. Storage on bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225-6, 229).
3. Environmental Monitoring

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

4. Housekeeping, Maintenance, and Inspections
   (a) Cleaning. Floors should be cleaned regularly (24).
   (b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).
   (c) Maintenance. Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Other safety equipment should be inspected regularly. (e.g., every 3-6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).
   (d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).
5. Medical Program
   (a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).
   (b) Routine surveillance. Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).
   (c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.
6. Protective Apparel and Equipment

These should include for each laboratory:

   (a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);
   (b) An easily accessible drench-type safety shower (162, 169);
   (c) An eyewash fountain (162)
   (d) A fire extinguisher (162-164);
   (e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and
   (f) Other items designated by the laboratory supervisor (156, 160).
7. Records
   (a) Accident records should be written and retained (174).

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

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

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

8. Signs and Labels

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

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

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

(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumption and storage are permitted (24); and

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

9. Spills and Accidents

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

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

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

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

10. Information and Training Program

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

(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154, 169).

Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6).

Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.

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

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

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

11. Waste Disposal Program.

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

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

(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27).

Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).

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

(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241).

Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14).

Hoods should not be used as a means of disposal for volatile chemicals (40, 200).

Disposal by recycling (233, 243) or chemical decontamination (40, 230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals

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

1. General Rules

The following should be used for essentially all laboratory work with chemicals:

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

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

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

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

(b) Avoidance of "routine" exposure: Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23);

Do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199).

Inspect gloves (157) and test glove boxes (208) before use.

Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

(c) Choice of chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate (13).

(d) Eating, smoking, etc.: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24).

Avoid storage, handling, or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).

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

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

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

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

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

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

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

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

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

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

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

Remove laboratory coats immediately on significant contamination (161).

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

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

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

As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13).

Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200).

Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).

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

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

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

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

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

2. Working with Allergens and Embryotoxins

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

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

Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.

Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.

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

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

Examples: diisopropylfluorophosphate (41), hydrofluoric acid (43), hydrogen cyanide (45).

Supplemental rules to be followed in addition to those mentioned above (Procedure B of "Prudent Practices", pp. 39-41):

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

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

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

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

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

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

(f) Prevention of spills and accidents: Be prepared for accidents and spills (41).

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

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40).

If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

(g) Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40).

Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5. Animal Work with Chemicals of High Chronic Toxicity

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

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

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

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

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

F. Safety Recommendations

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

1. Corrosive agents: (35-6)
2. Electrically powered laboratory apparatus: (179-92)

3. Fires, explosions: (26, 57-74, 162-64, 174-5, 219-20, 226-7)
4. Low temperature procedures: (26, 88)
5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27, 75-101)

G. Material Safety Data Sheets

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

* Acetyl peroxide (105)
* Acrolein (106)
* Acrylonitrile
Ammonia (anhydrous)(91)
* Aniline (109)
* Benzene (110)
* Benzo[a]pyrene (112)
* Bis(chloromethyl) ether (113)
Boron trichloride (91)
Boron trifluoride (92)
Bromine (114)
* Tert-butyl hydroperoxide (148)
* Carbon disulfide (116)
Carbon monoxide (92)
* Carbon tetrachloride (118)
*Chlorine (119)
Chlorine trifluoride (94)
* Chloroform (121)
Chloromethane (93)
* Diethyl ether (122)
Diisopropyl fluorophosphate (41)
* Dimethylformamide (123)
* Dimethyl sulfate (125)
* Dioxane (126)
* Ethylene dibromide (128)
* Fluorine (95)
* Formaldehyde (130)
* Hydrazine and salts (132)
Hydrofluoric acid (43)
Hydrogen bromide (98)
Hydrogen chloride (98)
* Hydrogen cyanide (133)
* Hydrogen sulfide (135)
Mercury and compounds (52)
* Methanol (137)
* Morpholine (138)
* Nickel carbonyl (99)
* Nitrobenzene (139)
Nitrogen dioxide (100)
N-nitrosodiethylamine (54)
* Peracetic acid (141)
* Phenol (142)
* Phosgene (143)
* Pyridine (144)
* Sodium azide (145)
* Sodium cyanide (147)
Sulfur dioxide (101)
* Trichloroethylene (149)
* Vinyl chloride (150)

Appendix B 10 1910.1450—References (Non-Mandatory)

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

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

1. American Chemical Society, Safety in Academic Chemistry Laboratories, 4th edition, 1985.
2. Fawcett, H.H. and W.S. Wood, Safety and Accident Prevention in Chemical Operations, 2nd edition, Wiley-Interscience, New York, 1982.
3. Flury, Patricia A., Environmental Health and Safety in the Hospital Laboratory, Charles C. Thomas Publisher, Springfield IL, 1978.
4. Green, Michael E. and Turk, Amos, Safety in Working with Chemicals, Macmillan Publishing Co., NY, 1978.
5. Kaufman, James A., Laboratory Safety Guidelines, Dow Chemical Co., Box 1713, Midland, MI 48640, 1977.
6. National Institutes of Health, NIH Guidelines for the Laboratory use of Chemical Carcinogens, NIH Pub. No. 81-2385, GPO, Washington, DC 20402, 1981.
7. National Research Council, Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, DC, 1983.
8. National Research Council, Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, DC, 1981.
9. Renfrew, Malcolm, Ed., Safety in the Chemical Laboratory, Vol. IV, J. Chem. Ed., American Chemical Society, Easlon, PA, 1981.
10. Steere, Norman V., Ed., Safety in the Chemical Laboratory, J. Chem. Ed. American Chemical Society, Easlon, PA, 18042, Vol. I, 1967, Vol. II, 1971, Vol. III, 1974.
11. Steere, Norman V., Handbook of Laboratory Safety, the Chemical Rubber Company Cleveland, OH, 1971.
12. Young, Jay A., Ed., Improving Safety in the Chemical Laboratory, John Wiley & Sons, Inc. New York, 1987.

(b) Hazardous Substances Information:

1. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, 6500 Glenway Avenue, Bldg. D-7, Cincinnati, OH 45211-4438.
2. Annual Report on Carcinogens, National Toxicology Program U.S. Department of Health and Human Services, Public Health Service, U.S. Government Printing Office, Washington, DC, (latest edition).
3. Best Company, Best Safety Directory, Vols. I and II, Oldwick, N.J., 1981.
4. Bretherick, L., Handbook of Reactive Chemical Hazards, 2nd edition, Butterworths, London, 1979.
5. Bretherick, L., Hazards in the Chemical Laboratory, 3rd edition, Royal Society of Chemistry, London, 1986.
6. Code of Federal Regulations, 29 CFR part 1910 subpart Z. U.S. Govt. Printing Office, Washington, DC 20402 (latest edition).
7. IARC Monographs on the Evaluation of the Carcinogenic Risk of chemicals to Man, World Health Organization Publications Center, 49 Sheridan Avenue, Albany, New York 12210 (latest editions).
8. NIOSH/OSHA Pocket Guide to Chemical Hazards. NIOSH Pub. No. 85-114, U.S. Government Printing Office, Washington, DC, 1985 (or latest edition).
9. Occupational Health Guidelines, NIOSH/OSHA. NIOSH Pub. No. 81-123 U.S. Government Printing Office, Washington, DC, 1981.
10. Patty, F.A., Industrial Hygiene and Toxicology, John Wiley & Sons, Inc., New York, NY (Five Volumes).
11. Registry of Toxic Effects of Chemical Substances, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Revised Annually, for sale from Superintendent of documents US. Govt. Printing Office, Washington, DC 20402.
12. The Merck Index: An Encyclopedia of Chemicals and Drugs. Merck and Company Inc. Rahway, N.J., 1976 (or latest edition).
13. Sax, N.I. Dangerous Properties of Industrial Materials, 5th edition, Van Nostrand Reinhold, NY., 1979.
14. Sittig, Marshall, Handbook of Toxic and Hazardous Chemicals, Noyes Publications. Park Ridge, NJ, 1981.

(c) Information on Ventilation:

1. American Conference of Governmental Industrial Hygienists Industrial Ventilation (latest edition), 6500 Glenway Avenue, Bldg. D-7, Cincinnati, Ohio 45211-4438.
2. American National Standards Institute, Inc. American National Standards Fundamentals Governing the Design and Operation of Local Exhaust Systems ANSI Z 9.2-1979 American National Standards Institute, N.Y. 1979.
3. Imad, A.P. and Watson, C.L. Ventilation Index: An Easy Way to Decide about Hazardous Liquids, Professional Safety pp 15-18, April 1980.
4. National Fire Protection Association, Fire Protection for Laboratories Using Chemicals NFPA-45, 1982.
   Safety Standard for Laboratories in Health Related Institutions, NFPA, 56c, 1980.
   Fire Protection Guide on Hazardous Materials, 7th edition, 1978.
   National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.
5. Scientific Apparatus Makers Association (SAMA), Standard for Laboratory Fume Hoods, SAMA LF7-1980, 1101 16th Street, NW., Washington, DC 20036.

(d) Information on Availability of Referenced Material:

1. American National Standards Institute (ANSI), 1430 Broadway, New York, NY 10018.
2. American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.

APPENDIX C

St. Olaf College Policy on Chemical-resistant Splash Goggles and Contact Lenses

"Approved eye protection is required for all people in all locations where a chemical hazard has been identified."**

** No chemical hazard exists when all chemicals are appropriately stored, that is placed in closed, designated cabinets, and chemicals are not in use. Chemicals located on bench tops, carts, or open shelving are readily available for use and, as such, pose a chemical hazard.

Why Goggles Must Be Worn

Handling hazardous chemicals can be a dangerous; consequently, St. Olaf College employees and students who handle such chemicals must make safety their highest priority. Federal and state laws mandate that persons working in potentially hazardous environments wear personal protective equipment (PPE).[1-4] While little that laboratory workers at St. Olaf College do is intrinsically dangerous, a majority of the materials that are handled are in some way potentially dangerous if they are handled carelessly. Perhaps the greatest potential danger in laboratory work will be from corrosive substances, such as strong acids and bases, that readily attack human tissues.

One of the most vulnerable parts of the body is the eyes and they must be protected from chemical splashes. Minnesota law requires students to wear eye protective devices.[2]

> *Subdivision 1. Requirement to wear eye protective devices. Every person shall wear industrial quality eye protective devices when participating in, observing or performing any function in connection with, any courses or activities taking place in eye protection areas, as defined in subdivision 3, of any school, college, university or other educational institution in the state.*
>
> *Subd. 3. Eye protection areas. Eye protection areas shall include, but not to be limited to, vocational or industrial art shops, science or other school laboratories, or school or institutional facilities in which activities are taking place and materials are being used involving:*
>
> *(1) hot molten metals;*
> *(2) milling, sawing, turning, shaping, cutting, grinding or stamping of any solid materials;*
> *(3) heat treatment, tempering or kiln firing of any metal or other materials;*
> *(4) gas or electric arc welding;*
> *(5) repair or servicing of any vehicle or mechanical equipment;*
> *(6) any other activity or operation involving work in any area that is potentially hazardous to the eye.*

Therefore, approved safety goggles must be worn at all times (covering the eyes) when you are working with chemicals, in the vicinity of others using chemicals, or in rooms where chemicals are available for use. Your laboratory supervisor will remind you to wear safety goggles and you will not be permitted to work in the laboratory if you do not wear them.

If you have a problem with goggles fogging, or if prolonged wear of goggles is uncomfortable, we recommend that you go into the hallways to remove the goggles for relief; be sure to put them back on before returning to the lab. Goggles should not be removed in the laboratory, unless your laboratory supervisor has instructed you to do so and announced that no chemical hazard exists. Several models of goggles are available; all models provide impact and splash protection and conform to Type H in ANSI Z87.1-2003 ("Occupational and Educational Personal Eye and Face Protection Devices").

Contact lenses

In the past, the chemical profession and others have been concerned about the use of contact lenses in potentially hazardous environments. However, the American Chemical Society and the American Optometric Association, among others, have issued new statements regarding contact lens use. OSHA's preamble for the final rule on PPE in 1994 states: "OSHA believes that contact lenses do not pose additional hazards to the wearer and additional regulation is unnecessary."[4]

The ACS states, "Recent studies and experience have suggested that, in fact, contact lenses do not increase risks but can actually minimize or prevent injury in many situations. Because of the ever-increasing use of contact lenses and the benefits they provide, the American Chemical Society Committee on Chemical Safety, having studied and reviewed the issue, is of the consensus that contact lenses can be worn in most work environments provided the same approved eye protection is worn as required of other workers in the area." [5]

Approved eye protection is required for faculty, staff, students and visitors in locations where a chemical hazard has been identified, regardless of whether or not the person wears contact lenses.

ANSI Z87.1-2003. Occupational and Educational Personal Eye and Face Protection Devices. This Selection Chart, taken from the ANSI Z87.1-2003 Standard, shows the types of eye and face protectors that are available, their capabilities and limitation for the hazard "source" operations listed. All St. Olaf College employees are required to wear Type H goggles when handling hazardous chemicals.

References:

(1) National Research Council (U.S.). Committee on Prudent Practices for Handling Storage and Disposal of Chemicals in Laboratories.; National Research Council (U.S.). Board on Chemical Sciences and Technology. *Prudent practices in the laboratory : handling and disposal of chemicals*; National Academy Press: Washington, D.C., 1995.

(2) In *Student Rights, Responsibilities, and Behavior: Eye Protective Devices*, 2001; Minnesota Statute §121.A32.

(3) In *Occupational Safety and Health Administration*, 2001; 29 CFR 1910.1450.

(4) In *Occupational Safety and Health Administration*, 2001; 29 CFR 1910.132-.138.

(5) Committee on Chemical Safety, A. C. S. *Safety in the Academic Chemistry Laboratories*, 6th ed.; American Chemical Society: Washington, D.C., 1995.

APPENDIX D

Fume Hood Experiment Activity Tag

Reporting Fume Hood Alarms (Written by P. Jackson & P. Ceas)

Chemical Hood Basics:
Laboratory hoods control exposure to toxic, offensive and flammable vapors. An appropriately functioning hood requires adequate airflow and an absence of turbulence. Air moves from the lower front of the hood to the back and then out ductwork at the top of the unit. Objects placed near the exit vents in a fume hood can cause disruption of air currents and even block airflow. Typically work is performed with the sash below the maximum opening that yields good airflow and at the lowest comfortable setting for the operator. Equipment and materials are manipulated at a distance about 15 cm from the sash opening. The acceptable operating airflow range for fume hoods is 80 to 120 linear feet per minute at the designated sash height (usually 18 inches). Fume hoods must be monitored daily by the user to ensure that air is moving into the hood.

Air Velocity Indicator:
All laboratory chemical fume hoods at St. Olaf College are equipped with a Dwyer Air Velocity Monitor (Series 660) that continuously monitors the airflow. As the exhaust fan draws air through the device, a sensitive constant temperature thermistor measures flow and lights a green (normal), yellow (high) or red (low) LED. While this device does not ensure optimal operation of the hood, it provides valuable feedback to the user.

An audible alarm warns of low flow and requires manual resetting.

Alarm Procedures:

1. Upon hearing an audible alarm, the observer should identify the laboratory space emitting the signal. If the observer is not in the lab space, determine if it appears safe to enter.
2. Identify the specific hood that is the source of the alarm.
3. Check to see if the bottom of the sash is below the label marking the maximum operating height; label is located on either side of the sash track. If the sash is above the marks, carefully lower the sash and wait 15-20 seconds to see if the alarm shuts off.
4. **If the alarm continues to sound**, press the "ACK." button on the indicator to acknowledge the alarm. *Record the room number, hood location and exhaust fan number*. The exhaust fan number is generally found on the upper left switch panel and contains three letters followed by two numbers [EXH-##].
5. Look for a Hood Activity Tag. The tag contains information about the current use of the hood and contact information for the faculty/staff supervisor and experimenter. *If there is no tag present proceed to step 7 (a or c).*
6. If a hood tag is present
   - Examine the lower right corner of the tag ("If Alarm will not stop, does this hood need immediate repair?").
   - If "Yes" is circled, then emergency repair is needed. *Proceed to step 7b.*
   - If "No" is circled, then p*roceed to step 7c.*

7a. ***Alarm during chemistry stockroom hours***
During chemistry stockroom hours (8 am – 4:30 pm), the observer should inform the chemistry stockroom manager about the equipment alarm, providing room number, location of hood and exhaust fan number. The stockroom manager will contact facilities to set up a repair schedule.

Alarm outside chemistry stockroom hours

7b. Emergency Repair Needed:
- The observer must contact the on-call St. Olaf Facilities operator so that the equipment alarm can be recorded and suitable repair protocol initiated.
- *If no one answers the Facilities phone then call the Public Safety 24 Hr emergency number.*
- The observer will also email and/or send a phone message to the chemistry stockroom manager and the chemical hygiene officer informing them of the equipment alarm and action.

7c. Reporting Only: The observer will email and/or send a phone message to the chemistry stockroom manager and the chemical hygiene officer informing them of the equipment alarm, its location, exhaust fan number and time of occurrence. The people will follow up on the alarm during the next business day.

Contact Information:

Chemistry Stockroom Manager	Michelle Howe	3401	howem@stolaf.edu
Chemical Hygiene Officer	Pat Ceas	3560	ceas@stolaf.edu
After hours emergency repair:			
St. Olaf Facilities		3281	
St. Olaf Public Safety 24 Hr		3666	

Example of Hood Tag:

CAUTION: EXPERIMENT IN PROGRESS

Start Date & Time:

End Date & Time:

Experimenter's Name:

Supervisor's Name

Work phone _____
Home phone _____
Email _____

Brief Description of Experiment:

If Alarm will not stop, does this hood need emergency repair? (circle one)

YES NO

If YES is circled, then contact:

Regular Hours (8am – 4:30pm)
Michelle Howe (-3401)
Pat Ceas (-3560)

After Hours (8am – 4:30pm)
Facilities (-3281)
Public Safety (-3666)

APPENDIX E

Laboratory Inspection Checklist

St. Olaf Laboratory Safety Inspection Sheet

Building & Room: _____ **Date:** _____

Room Use: _____

Department: _____ **Inspected By:** _____

Lab Supervisor: _____ **Is a follow-up inspection needed?** ____

Safety Information	**Yes**	**No**	**Comments**
CHP and all appropriate MSDS's present and understood			
Written lab-specific SOP's present and understood			
Emergency numbers/names posted by phones			
Special hazard assessments are written and posted			
Safety Signs in good condition			
PPE & Hygiene			
Goggles used if chemical hazard is present			
Additional PPE available and used as needed			
Footwear/clothing is appropriate (e.g., no sandals)			
No loose hair or clothing			
Food/Drink: No evidence of food or beverages in any lab			
Chemical Use and Storage			
Container dates: (1) Purchase, (2) Open, (3) Decision			
Containers are labeled properly for contents & hazards			
2° containment, for both "stored" and "in use" items			
Incompatible chemicals are physically separated			
Containers closed tightly, in good condition, no leaks			
Not "stored" on/in bench tops, hoods, under sinks, floor			
Containers not stacked; liquids stored below eye level			
Shelves are not crowded; easy access to individual jars			
Flammables in lab within allowed quantities			
Unstables/Explosives/Peroxide Formers ID'd, dated, tested			
Hazardous & Other Waste			
All Hazardous Waste containers clearly labeled			
Container ingredients clearly labeled			
HW containers closed (even if in fume hood)			
HW containers kept only in designated SAPs			
Secondary containment used; incompatibles separated			
Sharps containers used and labeled			
Biohazard containers/bags used and labeled			
Glassware and Other Lab Equipment			
Glassware under pressure/vacuum is taped/caged; shielded			
All glassware in good shape (no cracks, chips)			
All equipment in good working condition			
Housekeeping			
Bench tops & sinks clean and unobstructed			
Faucet hoses are secure; faucets shut off properly			
Papers & other combustibles away from hotplates, etc.			

Furniture in good working order			
Shelves anchored to wall/floor (no tip over hazard)			
Step ladders available if necessary			
Good workplace ergonomics; heavy items stored low			
Refrigerators/freezers defrosted & clean			
Egress/Emergency Pathways			
Floor, aisles, exits are unobstructed; clean, not slippery			
File and desk drawers are closed			
Hall doors closed to maintain negative airflow			
Outside hallways uncluttered			
Fire Extinguishers			
Fully charged & inspected annually			
Not blocked by obstructions; identified by wall sign			
Other Safety Equipment			
Eye Wash & Safety Shower Stations:			
Tested weekly (eye wash) or monthly (shower)			
Access not blocked			
First Aid Kit with appropriate supplies			
Fire Blanket available			
Emergency lights work			
Spill kits complete			
Fume Hoods			
Air flow alarm functioning properly			
Workers are properly using the hood			
Sashes closed (except when manipulating items)			
Sashes unobstructed and open/close easily			
Sash glass is clean; view into hood unobstructed			
Hood space not crowded; no items blocking exhaust slot			
All items placed at least 6 inches inside hood			
Electrical Equipment			
Circuits not overloaded; breakers unobstructed, labeled			
Surge protection on power strips; GFCI as needed			
Equipment grounded			
Cords well placed, in good shape, away from water			
Gas Cylinders & Liquid Nitrogen			
Individually secured by strap/chain; not blocking aisles			
Contents labeled			
Cap on unused tanks			
Full/Empty tag			
Proper PPE used while dispensing liquid nitrogen			
Other Safety Concerns			
Lasers, Biohazards, Bloodborne pathogens			
Doors, ceilings, pipes, etc.			