U of MN Characterization Facility

Laboratory Safety Plan

Updated: August, 2012 Reviewed:___________

Chapter 1 - Introduction

1. Purpose

This Laboratory Safety Plan (LSP) describes policies, procedures, equipment, personal protective equipment and work practices that are capable of protecting employees and users of this Facility from the health hazards in laboratories. This Plan is intended to meet the requirements of the federal Laboratory Safety Standard, formally known as "Occupational Exposure to Hazardous Chemicals in Laboratories", a copy of which is found in Appendix A. This LSP also addresses the concerns of the Minnesota Employee Right To Know Act (MERTKA) and the federal Toxic Substance Control Act (TSCA).

This LSP is intended to safely limit laboratory workers' exposure to OSHA- and MERTKA-regulated substances. Laboratory workers must not be exposed to substances in excess of the permissible exposure limits (PEL) specified in OSHA rule 29 CFR 1910, Subpart Z, Toxic and Hazardous Substances. PELs for regulated substances are provided in Appendix B. PELs refer to airborne concentrations of substances and are averaged over an eight-hour day. A few substances (listed under Individual Chemical Standard in the Federal column in Appendix C) also have "action levels". Action levels are air concentrations below the PEL which nevertheless require that certain actions such as medical surveillance and workplace monitoring take place. 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.

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.

Toxic Substances Control Act (TSCA) requires that prudent laboratory practices be developed and documented for research involving new chemicals that have not had their health and environmental hazards fully characterized. Laboratories engaged in research must consider the applicability of the Toxic Substances Control Act (TSCA) on their operation. TSCA, administered by the U.S. Environmental Protection Agency (EPA) under the New Chemicals Program [http://www.epa.gov/oppt/newchems/], is intended to ensure that the human health and environmental effects of chemical substances are identified and adequately addressed prior to commercial use or transport of those substances. A new chemical is a chemical substance that is produced or imported and not yet listed on the TSCA Chemical Substance Inventory. Each laboratory or research group that synthesizes or imports new chemicals must determine if and how TSCA applies to their laboratory activities – see Appendix O.

2. Scope and Application

This Laboratory Safety Plan covers The University of Minnesota Characterization Facility (CharFac), including the locations in Shepherd Labs and Nils Hasselmo Hall (NHH).

The Laboratory Safety Standard applies where 'laboratory use' of hazardous chemicals occurs. Laboratory use of hazardous chemicals means handling or use of such chemicals in which all of the following conditions are met:

i. the handling or use of chemicals occurs on a 'laboratory scale', that is, the work involves containers which can easily and safely be manipulated by one person,
ii. multiple chemical procedures or chemical substances are used, and
iii. protective laboratory practices and equipment are available and in common use to minimize the potential for employee exposures to hazardous chemicals.

At a minimum, this definition covers employees (including student employees, technicians, supervisors, lead researchers and physicians) who use chemicals in teaching, research and clinical laboratories at the University of Minnesota. Certain non-traditional laboratory settings may be included under this standard at the option of individual departments within the University. Also, it is the policy of the University 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.

This standard does not apply to laboratories whose function is to produce commercial quantities of material. Also, where the use of hazardous chemicals provides no potential for employee exposure, such as in procedures using chemically impregnated test media and commercially prepared test kits, this standard will not apply. The researchers listed in the following table are covered by this Laboratory Safety Plan.

Principal Investigator	Building	Room #	Primary research hazards
Bing Luo	Shepherd Labs	29	Confocal Raman, FTIR, microcontact angle, SPM/AFM, ellipsometry.
Chris Frethem	Nils Hasselmo	1-232	Scanning electron microscopy (including cryo and bio).
Michael Dupont	Shepherd Labs	53	Transmission electron microscopy, scanning electron microscopy.
Greg Haugstad	Shepherd Labs	201	SPM/AFM, Ion beam analysis (RBS/FReS, PIXE, NRA), ToF-SIMS
Bing Luo	Shepherd Labs	29	X-ray photoelectron spectroscopy, Auger spectroscopy/sputter profiling, X-ray diffraction
Nicholas Seaton	Shepherd Labs	53	SEM/EDS, nanomechanical testing, stylus profilometry, light microscopy, ellipsometry
Mike Manno	Shepherd Labs	14	X-ray scattering (XRD/SAXS)
Jason Myers	Shepherd Labs	55	TEM (HR/STEM/EDS/EELS), FIB
Wei Zhang	Nils Hasselmo	1-236	Cryo-TEM on bio and soft materials, tomography/3D reconstruction
Fang Zhou	Nils Hasselmo	1-234	(Cryo)microtomy, bio specimen prep, TEM (bio), SEM

3. Coordination With Other Standards and Guidelines

The Laboratory Safety Standard and MERTKA address occupational safety issues. Other federal, state and local standards that address use of hazardous chemicals and other materials are listed in Appendix C. Note particularly the listed chemicals with individual standards in the „Federal" column, since these compounds generally have *action limits* (usually set at half the TLV), *air monitoring requirements*, and *medical monitoring requirements.* If a researcher is using one of these chemicals, or in the unlikely event that there is a conflict between provisions of various standards, the Department of Environmental Health and Safety should be contacted.

4. Responsibilities

Implementation of the Laboratory Safety Standard at the University is a shared responsibility. Employees, supervisors, Research Safety Officers, department heads, deans, upper administrative staff, and DEHS staff all have roles to play. These roles are outlined below.

A. President - Robert H. Bruininks, Vice President for Research - R. Timothy Mulcahy

Upper level administrators are responsible for:

- promoting the importance of safety in all activities;
- promoting the same attitude among all levels of employment at the University;
- supporting a broad-based laboratory safety/chemical hygiene program that will protect U of MN laboratory employees from health effects associated with hazardous chemical, physical or biological agents; and
- ensuring that deans, directors and department heads provide adequate time and recognition for employees who are given laboratory safety responsibilities.

Performance will be measured by:

- DEHS's documentation and annual reporting of the level of compliance within each of the reporting units.

Dean - Steven Crouch, CharFac Director - Greg Haugstad

DDDs are responsible for:

- identifying at least one technically-qualified research safety officer for the unit. (Colleges or institutes that are made up of a number of large laboratory-based departments are urged to assign research safety officers within each department. Large departments may assign one research safety officer for each division);
- transmitting the name of the designated research safety officer to the U of MN's Chemical Hygiene Officer;
- ensuring that the designated research safety officer is adequately trained regarding the roles and responsibilities of the position;
- ensuring that the designated research safety officer modifies this generic Laboratory Safety Plan to incorporate location-specific information;
- carries out his/her assigned responsibilities
- evaluating the performance of the research safety officer(s) as part of overall job performance; and
- taking appropriate measures to assure that college/department/division activities comply with University and OSHA laboratory safety policies;

Performance will be measured by:

- DEHS's record of a trained, research safety officer for the unit.
- DEHS's record of a current, tailored Laboratory Safety Plan for the unit.

B. Department of Environmental Health and Safety (DEHS)

The Chemical Hygiene Officer for the University is Dawn Errede, and the entire DEHS staff will participate in providing resources for departments in the development of their individual health and safety programs. The Department of Environmental Health and Safety is responsible for:

- preparing and updating the University's generic Laboratory Safety Plan;
- distributing the LSP to departments or other units who will tailor and implement the plan;
- training designated departmental research safety officers regarding their responsibilities for safety and compliance with regulations and University standards that apply to research; and
- monitoring the progress of departments toward achieving compliance.

Performance will be measured by

- DEHS's documentation that review and evaluation of the generic LSP occurs at least annually, updates as necessary;
- annual feedback to DDDs regarding DEHS's records of Health and Safety compliance status for each unit.

C. Research Safety Officer – Bing Luo

The RSO's roles and responsibilities are described in greater detail in the RSO Toolkit. Briefly, the RSO will:

- serve as liaison between employing department and the Department of Environmental Health and Safety;
- know the rules, to help researchers comply with applicable state, federal and university requirements;
- develop and implement a Laboratory Safety Plan for the department;
- coordinate training to ensure all researchers understand their responsibilities and the policies that apply to their research.
- coordinate inspections of laboratories and ensure laboratory supervisors address any noted deficiencies;
- keep records to document compliance with state, federal and university requirements.

Performance will be measured by DEHS's documentation in a letter to the DDDs that:

- review and evaluation of the tailored LSP occurs at least annually;
- the research safety officer's personal training records are current;
- update training for lab researchers and supervisors occurs at least annually;
- labs are audited at least annually

D. Supervisors/Principal Investigators – Listed in section 2 of this Lab Safety Plan

The immediate supervisor of a laboratory employee is responsible for:

- assuring that potential hazards of specific projects have been identified and addressed before work is started;
- ensuring there are written, laboratory-specific standard operating procedures for the protocols carried out in the laboratory that incorporate directions about how to mitigate the hazards of the procedures.
- informing and training employees regarding the specific hazards in their area and in the work they will be doing;
- scheduling time for the employee to attend designated training sessions;
- enforcing U of MN safety policies and safe work practices;
- conducting periodic audits of the research space under the supervisors control;
- reporting hazardous conditions to the college or departmental research safety officer;
- investigate laboratory accidents and send an Accident Investigation Worksheet (Appendix N) with recommendations to the departmental research safety officer for review.

Performance will be measured by:

- home department's documentation of current, pertinent safety training for the supervisor and each employee in the supervisor's group;
- home department's documentation of regular audits for laboratory space under the control of the supervisor.

E. Employees – Listed in section 2 of this Lab Safety Plan

Employees who have significant responsibility for directing their own laboratory work are responsible for assuring that potential hazards of specific projects have been identified and addressed before work is started. All laboratory employees however, are responsible for:

- attending safety training sessions;
- following safety guidelines applicable to the procedures being carried out;
- assuring that required safety precautions are in place before work is started; and
- reporting hazardous conditions as they are discovered.

Performance will be measured by:

- supervisor's assessment of employee's adherence to topics covered in safety training.

U of MN Characterization Facility

Laboratory Safety Plan

Chapter 2 - Standard Operating Procedures

As noted in Chapter 1, Principal Investigators are responsible for ensuring there are written standard operating procedures (SOPs) for the research protocols conducted in their area. The SOPs must identify the hazards of the protocol, as well as measures to be taken to mitigate those hazards. The references listed below may provide enough detail to serve as the SOPs for some research protocols. Other protocols may require more tailoring, as described in Section 5 of this chapter.

1. Chemical Procedures

A. Prudent Practices in the Laboratory (Appendix D)

Laboratory standard operating procedures found in Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (National Research Council, 1995) are adopted for general use at the University of Minnesota. Departmental Research Safety Officers have hard copies of this text, and the entire contents are accessible on the web. Note especially the following topics which are covered in Chapters 5 and 6 of Prudent Practices:

Chapter 5 Working with Chemicals

- Introduction
- Prudent Planning
- General Procedures for Working with Hazardous Chemicals
- Working with Substances of High Toxicity
- Working with Biohazardous and Radioactive Materials
- Working with Flammable Chemicals
- Working with Highly Reactive or Explosive Chemicals
- Working with Compressed Gases

Chapter 6 Working with Laboratory Equipment

- Introduction
- Working with Water-Cooled Equipment
- Working with Electrically Powered Laboratory Equipment
- Working with Compressed Gases
- Working with High/Low Pressures and Temperatures
- Using Personal Protective, Safety, and Emergency Equipment
- Emergency Procedures

B. Controlled Substances and Alcohol

In conducting research with controlled substances, University authorized employees must comply with federal and state laws and regulations regarding their uses, including registration with the Drug Enforcement Administration (DEA), storage requirements, inventory maintenance and substance disposal. A condensed guide to federal regulations as well as policies and forms pertaining to controlled substances are available on the Controlled Substances webpage.

Alcohol used for education, scientific research, or medicinal purposes can be purchased tax-free through University Stores (www.ustores.umn.edu), which holds the University of Minnesota site license for alcohol purchases with the Federal Bureau of Alcohol, Tobacco, and Firearms (BATF). Further information and links to the ordering form are available by clicking on Tax Free Alcohol Ordering Procedures.

C. The American Chemical Society's "Safety in Academic Chemistry Laboratories"

ACS"s "Safety in Academic Chemistry Laboratories" is another useful text. This manual presents information similar to that found in Prudent Practices, but in a considerably condensed format.

D. Hazardous Waste Management

Extensive and detailed policies regarding hazardous waste management are specified in the University's guidebook "Hazardous Chemical Waste Management, 5th edition". Please refer to this text for approved waste handling procedures.

E. Emergency Procedures for Chemical Spills

The procedures listed below are intended as a resource for your department in preparing for emergencies before they happen. If you are currently experiencing an emergency such as a chemical or blood spill, please contact the Department of Environmental Health and Safety at 612-626-6002.

Complete spill response procedures are described in the Hazardous Chemical Waste Management Guidebook. However, the quick reference guide is included for convenience in this Laboratory Safety Plan.

Quick Reference Guide

Evacuate

- Leave the spill area; alert others in the area and direct/assist them in leaving.
- Without endangering yourself: remove victims to fresh air, remove contaminated clothing and flush contaminated skin and eyes with water for 15 minutes. If anyone has been injured or exposed to toxic chemicals or chemical vapors, call 911 and seek medical attention immediately.

Confine

- Close doors and isolate the area. Prevent people from entering spill area.

Report

- From a safe place, call the Department of Environmental Health and Safety (EHS) (612) 626-6002 during working hours, 911 after hours (Twin Cities Campus 911 operators will contact on-call EHS personnel).
- Report that this is an emergency and give your name, phone and location; location of the spill; the name and amount of material spilled; extent of injuries; safest route to the spill.
- Stay by that phone, EHS will advise you as soon as possible.
- EHS or the Fire Department will clean up or stabilize spills, which are considered high hazard (fire, health or reactivity hazard). In the case of a small spill and low hazard situation, EHS will advise you on what precautions and protective equipment to use.

Secure

- Until emergency response personnel arrive: block off the areas leading to the spill, lock doors, post signs and warning tape, and alert others of the spill.
- Post staff by commonly used entrances to the area to direct people to use other routes.

After an accident, supervisor(s) must complete and fax in reporting forms within 24 hours. Workers' Compensation policy and reporting forms are available on the web (Appendix J).

2. Biohazardous Procedures

All researchers working with human blood or body fluids, or other pathogens must follow the university"s Exposure Control Plan, and complete Boodborne Pathogens Training, available on the web. All researchers working with infectious material including attenuated lab & vaccine strains (bacteria, viruses, parasites, fungi, prions), biologically-derived toxins, rDNA, and artificial gene transfer must follow requirements of the University"s Biosafety Program detailed in the Biosafety Manual and on the Institutiona l B ios af et y Com m ittee"s webs i te .

A. Biosafety Manual

The University"s Biosafety Manual is made up of three components; researchers must implement all three components in their lab safety manual.

- Biosafety Principles and Practices;
- CDC/NIH's text Biosafety in Microbiological and Biomedical Laboratories (BMBL).
- Individual lab-specific Standard Operating Procedures (SOPs) that:
  - specify the biohazards being used
  - identify the material handling steps that may pose a risk of exposure (sharps, injecting animals, centrifugation, aerosol production, transport, etc.)
  - describe equipment and techniques used to reduce the above risk of exposure
  - give instructions for what to do in case of an accidental exposure/spill
  - list wastes that will be generated and how to properly dispose of wastes

B. Institutional Biosafety Committee (IBC)

The IBC is charged under Federal Regulations (NIH) and University of Minnesota Regents" Policy with the oversight of all teaching and research activities involving:

- Recombinant DNA
- Artificial gene transfer
- Infectious agents including attenuated lab & vaccine strains
- Biologically derived toxins

See the IBC web site for procedures to apply for approval for the above work.

C. Select Agents

Labs in possession of organisms or toxins that are federally designated as select agents are required to be registered with the Centers For Disease Control if quantities exceed the exemption amounts. See the Biosafety Section of the DEHS web site for a list of select agents, exemption quantities, and procedures for their use.

D. Additional Biosafety References

World Health Organization (WHO) *Laboratory Safety Manual*, available on the web at, http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_CSR_LYO_2004_11/en/

National Research Council"s text *Biosafety in the Laboratory: Prudent Practices for Handling and Disposal of Infectious Materials* (1989), available on the web at http://books.nap.edu/books/0309039754/html/R1.html#pagetop.

Biological Material Safety Data Sheets (MSDS) available at http://www.phac-aspc.gc.ca/msds-ftss/index.html.

3. Radioactive Procedures

All researchers using radioactive materials at the University of Minnesota must:

- obtain a permit for the possession and use of radioactive materials (contact the Radiation Protection Division);
- complete required training modules; and
- comply with the radiation policies and procedures of the university (contained in the Radiation Protection manual).

The Radiation Protection manual contains information on a number of topics including license committees, the permitting process, purchasing procedures, transfer procedures, general safety, personnel dosimetry, waste management, emergency management (spill control), record keeping, and regulatory guides on occupational exposure and prenatal exposure.

Training is required for all personnel who require access to areas where radioactive materials are used or stored. This training can be completed on line (http://www.dehs.umn.edu/rad_radmat_training.htm).

4. General Safety Procedures

Other lab and general safety information is available on the University of Minnesota website as indicated below.

A. Lab Safety

- Emergency Eyewash and Safety Shower Installation (http://www.cppm.umn.edu/standards/AppendixS.pdf)
- Personal Protective Equipment for Animal Care and Use (http://www.ohs.umn.edu/ppe/home.html)
- Respiratory Protection for Lab Animal Allergens (http://www.ohs.umn.edu/laa/home.html)
- Controlled Substances (http://www.research.umn.edu/riop/controlsubst.htm)
- Lock Out/Tag Out (http://www.dehs.umn.edu/train_factsheet_lkouttagout.htm)
- Respiratory Protection Program (http://www.dehs.umn.edu/Docs/Respiratory%20Protection%20Program%20Instruction.doc)
- Hearing Conservation Program (http://www.ohs.umn.edu/hcp/home.html)
- Laboratory Close-out Procedure (http://www.dehs.umn.edu/Docs/LaboratoryCloseout.doc)

B. General Safety

- Emergency Procedures (http://www1.umn.edu/prepared/)
- Temperature Standard (http://www.dehs.umn.edu/iaq_tempstandards.htm)
- University of Minnesota Twin Cities Campus Smoke-Free Indoor Air Policy (http://www.policy.umn.edu/Policies/Operations/Safety/SMOKING.html)
- Supervisors Injury/Illness Investigation Form (http://www.policy.umn.edu/prod/groups/president/@pub/@forms/@hr/documents/form/supincidentinv.doc)

5. Laboratory-Specific Standard Operating Procedures

Each PI must have written Standard Operating Procedures (SOPs) for the research protocols conducted in his or her laboratory. Like the Lab Safety Plan, the SOPs must be accessible to researchers. Keeping hard copies in the lab or having them on a computer in the laboratory fulfills the accessibility requirement. SOPs developed through DEHS will be posted periodically in Appendix H.

Laboratory-specific SOPs are valuable research tools that supplement the departmental Laboratory Safety Plan. The process of writing SOPs requires an individual to think through all steps of a procedure and perform a risk assessment before beginning work. The SOP provides a written means to inform and advise researchers about hazards in their work place, allows for standardization of materials and methods, and improves the quality of the research. A well-written SOP can be used to comply with the federal Laboratory Safety Standard, which states that the Laboratory Safety Plan must include:

"standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals."

SOPs should include exposure controls and safety precautions that address both routine and accidental chemical, physical or biological hazards associated with the procedure. A laboratory safety information sheet is available in Appendix F. This checklist, which prompts researchers to identify hazards and safety measures for the protocol, can be attached to existing procedures which may lack safety information. A template for writing new SOPs is available in Appendix I and guidance for writing biologically-related SOPs is available on the Biosafety section of the DEHS website.

6. General Emergency Procedures

The procedures listed below are intended as a resource for your department in preparing for emergencies before they happen. If you are currently experiencing an emergency such as a chemical or blood spill, please contact the Department of Environmental Health and Safety at 612-626-6002.

For University employees who have been exposed to bloodborne or other infectious pathogens, please follow the procedures below under "Needle Stick." For all other emergencies call 911.

Campus Safety Information Guidebook
(http://www.dem.umn.edu/Emergency%20Response%20Guide/index.htm)

- bomb threats
- medical emergencies
- fire
- severe weather
- utility outages
- warning systems/sirens

Chemical Spills (http://www.dehs.umn.edu/hazwaste_chemwaste_umn_cwmgbk_sec3.htm)

First Aid for Laboratory and Research Staff (http://www.dehs.umn.edu/Docs/Lab_First_Aid.doc)

Needle Sticks (http://www.dehs.umn.edu/bio_pracprin_blood_needle.htm)

Radioactive Material Incidents (http://www.dehs.umn.edu/rad_radmat_incidents.htm)

Workplace Violence (contact Human Resources (ohr@umn.edu) for a hard-copy)

7. Planning for Shutdowns

Researchers should develop written procedures to deal with events such as loss of electrical power (affecting fume hoods, coolers etc.) or other utilities (water), or temporary loss of personnel due to illnesses such as pandemic flu. Guidance on factors to consider when developing shut-down plans is included in the Lab Hibernation Checklist in Appendix O.

U of MN Characterization Facility

Laboratory Safety Plan

Chapter 3 - Criteria for Implementation of Chemical Control Measures

Engineering controls, personal protective equipment, hygiene practices, and administrative controls each play a role in a comprehensive laboratory safety program. Implementation of specific measures must be carried out on a case-by-case basis, using the following criteria for guidance in making decisions. Assistance is available from the Department of Environmental Health and Safety.

1. Engineering controls

a) Fume Hoods

The laboratory fume hood is the major protective device available to laboratory workers. It is designed to capture chemicals that escape from their containers or apparatus and to remove them from the laboratory environment before they can be inhaled. Characteristics to be considered in requiring fume hood use are physical state, volatility, toxicity, flammability, eye and skin irritation, odor, and the potential for producing aerosols. A fume hood should be used if a proposed chemical procedure exhibits any one of these characteristics to a degree that (1) airborne concentrations might approach the action level (or permissible exposure limit), (2) flammable vapors might approach one tenth of the lower explosion limit, (3) materials of unknown toxicity are used or generated, or (4) the odor produced is annoying to laboratory occupants or adjacent units.

Procedures that can generally be carried out safely outside the fume hood include those involving (1) water-based solutions of salts, dilute acids, bases, or other reagents, (2) very low volatility liquids or solids, (3) closed systems that do not allow significant escape to the laboratory environment, and (4) extremely small quantities of otherwise problematic chemicals. The procedure itself must be evaluated for its potential to increase volatility or produce aerosols.

In specialized cases, fume hoods will contain exhaust treatment devices, such as water wash-down for perchloric acid use, or charcoal or HEPA filters for removal of particularly toxic or radioactive materials.

b) Safety Shields

Safety shields, such as the sliding sash of a fume hood, are appropriate when working with highly concentrated acids, bases, oxidizers or reducing agents, all of which have the potential for causing sudden spattering or even explosive release of material. Reactions carried out at non-ambient pressures (vacuum or high pressure) also require safety shields, as do reactions that are carried out for the first time or are significantly scaled up from normal operating conditions.

c) Biological Safety Cabinets

Biological Safety Cabinets (BSC), also known as tissue culture hoods or laminar flow hoods, are the primary means of containment for working safely with infectious microorganisms. Cabinets are available that either exhaust to the outside or that recirculate HEPA filtered air to the laboratory. They are not to be used for working with volatile or hazardous chemicals unless they are specifically designed for that purpose and are properly vented. Generally, the only chemical work that should be done in a BSC is that which could be done safely on a bench top involving chemicals that will not damage the BSC or the

HEPA filter. For proper cabinet selection and use see, the CDC publication Primary Containment for Biohazards.

d) Other Containment Devices

Other containment devices, such as glove boxes or vented gas cabinets, may be required when it is necessary to provide an inert atmosphere for the chemical procedure taking place, when capture of any chemical emission is desirable, or when the standard laboratory fume hood does not provide adequate assurance that overexposure to a hazardous chemical will not occur. The presence of biological or radioactive materials may also mandate certain special containment devices. High strength barriers coupled with remote handling devices may be necessary for safe use of extremely shock sensitive or reactive chemicals.

Highly localized exhaust ventilation, such as is usually installed over atomic absorption units, may be required for instrumentation that exhausts toxic or irritating materials to the laboratory environment. Ventilated chemical storage cabinets or rooms should be used when the chemicals in storage may generate toxic, flammable or irritating levels of airborne contamination.

2. Personal Protective Equipment

a) Skin Protection

As skin must be protected from hazardous liquids, gases and vapors, proper basic attire is essential in the laboratory. Long hair should be pulled back and secured and loose clothing (sleeves, bulky pants or skirts) avoided to prevent accidental contact with chemicals or open flames. Bare feet, sandals and open-toed or perforated shoes are not permitted in any laboratory. Short pants and short skirts are not permitted unless covered by a lab coat. Long pants should be worn to cover skin that could be exposed during a spill.

Lab coats are strongly encouraged as routine equipment for all laboratory workers. Remember that lab coats should be worn to protect employees against both chemical and biological hazards. Working in a biosafety level 1 laboratory does not excuse an employee from wearing a lab coat. It is the responsibility of the employer to purchase and wash lab coats for employees who request them or are required to wear them. Lab coats cannot be taken home for laundering. Lab coats are required when working with radioactive materials, biologically-derived toxins, Biosafety Level II organisms, carcinogens, reproductive toxins, substances which have a high degree of acute toxicity, and any substance on the OSHA PEL list carrying a "skin" notation. See Appendix B for chemical listings. Lab coats cannot be assumed to provide complete protection against all agents, but will provide an extra layer that can be removed if accidentally contaminated, buying time for the researcher to get to the emergency shower and minimize direct skin contact. For strong acids and bases, a lab apron impervious to liquids would be a more appropriate choice.

Gloves made of appropriate material are required to protect the hands and arms from thermal burns, cuts, or chemical exposure that may result in absorption through the skin or reaction on the surface of the skin. Gloves are also required when working with particularly hazardous substances where possible transfer from hand to mouth must be avoided. Thus gloves are required for work involving pure or concentrated solutions of select carcinogens, reproductive toxins, substances which have a high degree of acute toxicity, strong acids and bases, and any substance on the OSHA PEL list carrying a "skin" notation.

Since no single glove material is impermeable to all chemicals, gloves should be carefully selected using guides from the manufacturers. General selection criteria are outlined in Prudent Practices, p. 132, and glove selection guides are available on the web . However, glove-resistance to various chemicals materials will vary with the manufacturer, model and thickness. Therefore, review a glove-resistance chart from the manufacturer you intend to buy from before purchasing gloves. When guidance on glove selection for a particular chemical is lacking, double glove using two different materials, or purchase a multilayered laminated glove such as a Silvershield or a 4H.

b) Eye Protection

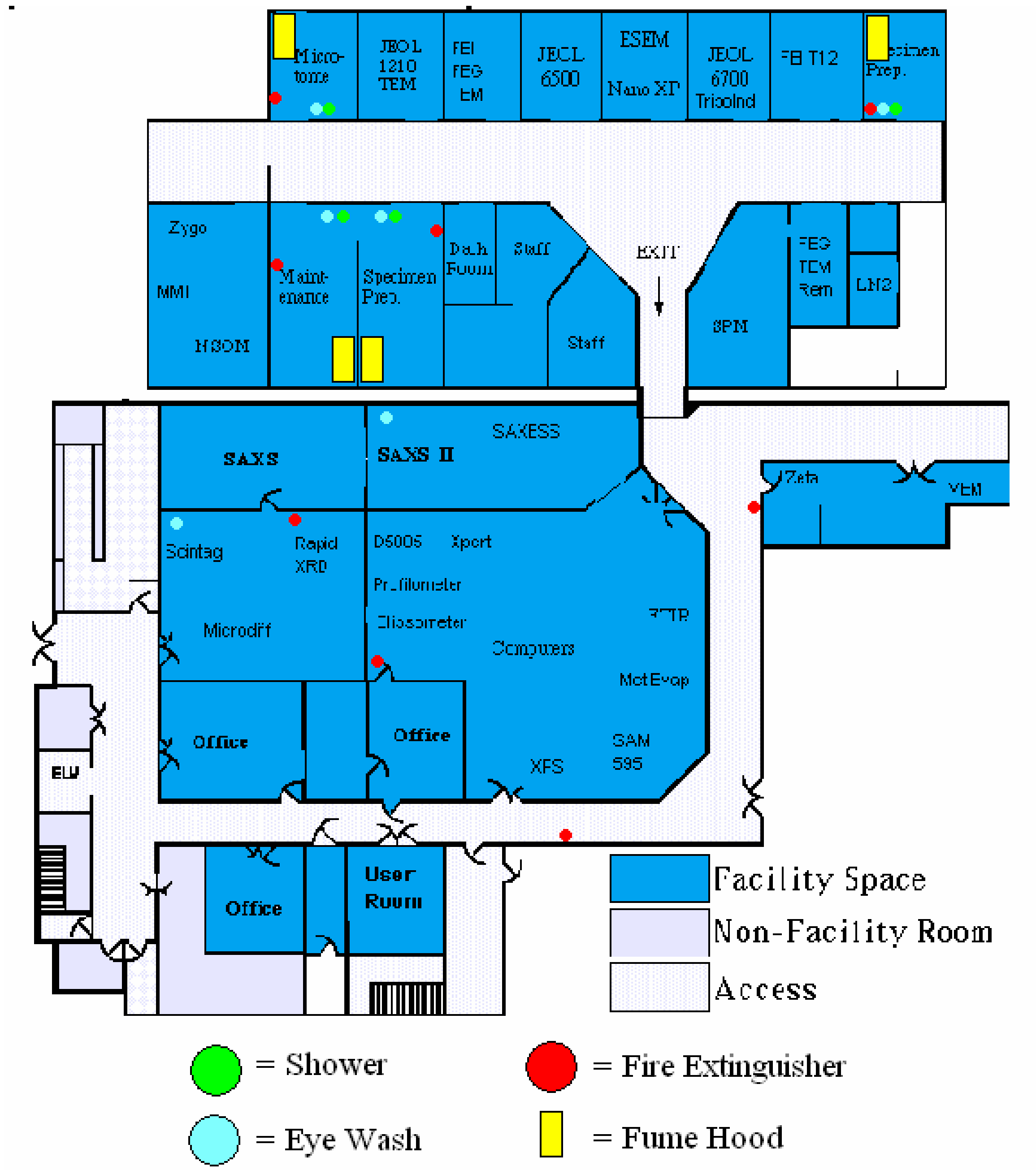
Eye protection is required for all personnel and any visitors whose eyes may be exposed to chemical or physical hazards. Side shields on safety spectacles provide some protection against flying particles, but goggles or face shields are necessary when there is a greater than average danger of eye contact with liquids. A higher than average risk exists when working with highly reactive chemicals, concentrated corrosives, or with vacuum or pressurized glassware systems. Contact lenses may be worn under safety glasses, goggles or other eye and face protection. Experts currently believe the benefits of consistent use of eye protection outweigh potential risks of contact lenses interfering with eye flushing in case of emergency.

c) Respiratory Protection

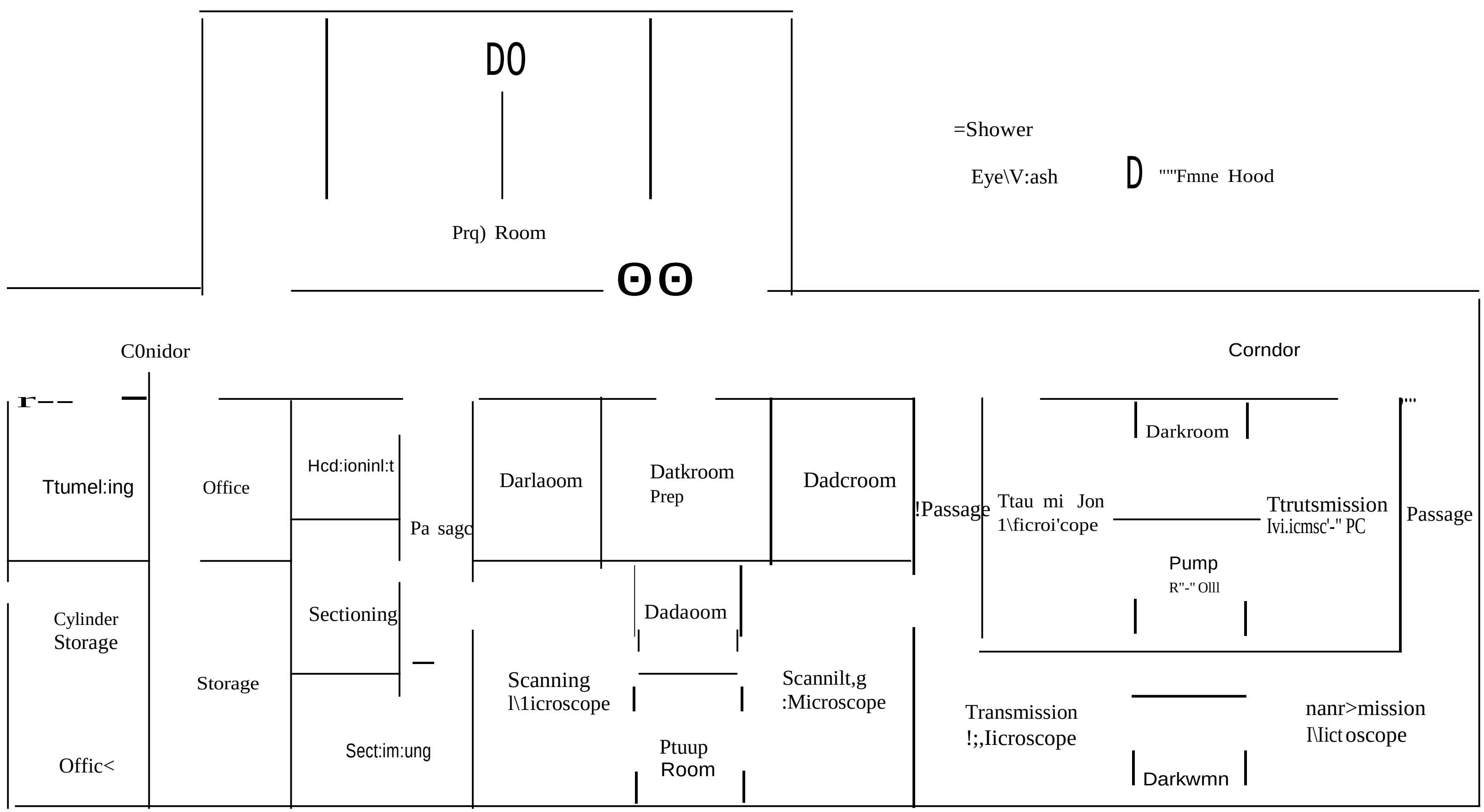
Respiratory protection is generally not necessary in the laboratory setting and must not be used as a substitute for adequate engineering controls. Availability of respiratory protection for emergency situations may be required when working with chemicals that are highly toxic and highly volatile or gaseous. If an experimental protocol requires exposure above the action level (or PEL) that cannot be reduced, respiratory protection will be required. Rarely, an experimental situation may potentially involve IDLH (immediately dangerous to life or health) concentrations of chemicals, which will require use of respiratory protection. All use of respiratory protective equipment is covered under the University of Minnesota Respiratory Protection Program.

d) Location of Safety Equipment

Floor maps showing the location of engineering controls are given on the next two pages.



Floor map of CharFac - Shepherd Labs, showing location of safety equipment


Prq) Room
=Shower
Eye\V:ash
""Fmne Hood
C0nidor
Corndor
Ttumel:ing
Office
Hcd:ioninl:t
Pa sagc
Darlaoom
Datkroom
Prep
Dadcroom
!Passage
Darkroom
Ttau mi Jon
1\ficroi'cope
Ttrutsmission
Ivi.icmsc'-" PC
Passage
Pump
R"-" Olll
Cylinder
Storage
Sectioning
Dadaoom
Storage
Scanning
l\1icroscope
Scannilt,g
:Microscope
Transmission
!;,Iicroscope
nanr>mission
I\lict oscope
Sect:im:ung
Ptuup
Room
Offic<
Darkwmn

3. Hygiene Practices

Eating, drinking and chewing gum are all strictly prohibited in any laboratory with chemical, biological or radioactive materials. Researchers must also be careful to restrict other actions (such as applying lip balm, rubbing eyes or using ipods or cell phones) which could inadvertently cause exposure to research materials. Consuming alcohol or taking illegal drugs in a research laboratory are strictly prohibited, as such actions potentially endanger the health and safety of not only the user, but everyone in the building. Infractions will be met with serious disciplinary action.
Before leaving the laboratory, remove personal protective equipment/clothing (lab coat and gloves) and wash hands thoroughly. Do NOT wear laboratory gloves, lab coats or scrubs in public spaces such as hallways, elevators or cafeterias.

4. Administrative Controls

Supervisors shall consider the hazards involved in their research, and in written research protocols, detail areas, activities, and tasks that require specific types of personal protective equipment as described above. Researchers are strongly encouraged to prioritize research so that work with hazardous chemical, biological or physical agents occurs only during working hours (8 am – 5 pm, Monday through Friday). After-hours work (on nights and weekends) should be restricted to nonhazardous activities such as data analysis and report writing. If hazardous materials must be used at nights or on weekends, ensure that at least one other person is within sight and ear-shot to provide help in an emergency. Undergraduate workers are prohibited from working alone in the laboratory unless there is a review and formal approval by the department‟s RSO and/or safety committee.

Research Safety Officers must coordinate and/or conduct inspections of laboratories in their area of responsibility and ensure laboratory supervisors address any noted deficiencies. An audit checklist is available in Appendix G. RSOs can report cases of continued non-compliance to the unit head and to the Department of Environmental Health and Safety (DEHS). The RSO, in conjunction with DEHS and the unit head, has the authority to halt research activities that present an imminent hazard.

In the event that a research lab is moving or leaving the university altogether, the principle investigator is responsible for cleaning up the lab space. If the principle investigator does not take proper care to clean-up the laboratory, then the department for which they worked under becomes responsible. We strongly encourage departments to develop administrative controls to prevent this from happening. A good tool to use is the laboratory closeout checklist available on the DEHS website. Otherwise, DEHS does offer laboratory clean-up services for an hourly fee.

U of MN Characterization Facility

Laboratory Safety Plan

Chapter 4 - Management of Chemical Fume Hoods and Other Protective Equipment

1. Monitoring Safety Equipment

Fume hoods must be monitored daily by the user to ensure that air is moving into the hood. Any malfunctions must be reported immediately to Facilities Management (612-624-2900). The hood should have a continuous reading device, such as a pressure gauge, to indicate that air is moving correctly. Users of older hoods without continuous reading devices should attach a strip of tissue or yarn to the bottom of the vertical sliding sash. The user must ensure the hood and baffles are not blocked by equipment and bottles, as air velocity through the face may be decreased. DEHS staff will measure the average face velocity of each fume hood annually with a velometer or a thermoanemometer. A record of monitoring results will be made.

If biological safety cabinets are used for Biosafety Level 2 work, including handling human cells, they must be certified annually by an outside contractor. A list of contractors is available on the Biosafety section of the DEHS web site. It is the responsibility of the department to schedule and pay for the contractor to perform annual certification.

Eye washes must be flushed weekly by the user. This will ensure that the eye wash is working, and that the water is clean, should emergency use become necessary. The user should post a log near the eye wash to document that it is being flushed every week. These logs are considered equipment maintenance records and therefore, should be kept for 1 year. An eyewash record template is available through the DEHS website. The user should also coordinate with Facilities Management to ensure that emergency showers and eye washes are tested annually. Facilities Management will document their testing on separate tags.

Fire extinguishers will be checked annually by a University contractor. The user is responsible for checking regularly to ensure that other protective equipment is functioning properly. Environmental Health and Safety staff can assist with these evaluations, should assistance be necessary.

General laboratory conditions must be monitored periodically by the users. A generic laboratory audit form is included in Appendix G, and may be tailored for use by individual laboratories. The departmental Research Safety Officer or the University's Chemical Hygiene Officer may also use this form for spot-checks of the laboratories.

2. Acceptable Operating Range

The acceptable operating range for fume hoods is 80 to 150 linear feet per minute, at the designated sash opening (usually 18 inches). If, during the annual check, a hood is operating outside of this range, DEHS staff may request that you check to ensure the baffles are adjusted properly, and that the exhaust slots are not blocked by bottles and equipment. If these adjustments do not help, DEHS staff will report the deficiency to the appropriate Facilities Management zone office for servicing.

3. Maintenance

During maintenance of fume hoods, laboratories must clean out and if necessary, decontaminate the fume hood and restrict use of chemicals to ensure the safety of maintenance personnel.

4. Training

Training in the appropriate use and care of fume hood systems, showers, eyewashes and other safety equipment must be included in the initial and update training described in Section 5.

5. New Systems

When new ventilation systems, such as variable air volume exhaust, are installed in University facilities, specific policies for their use will be developed by the Department of Environmental Health and Safety and employees will be promptly trained on use of the new equipment.

U of MN Characterization Facility

Laboratory Safety Plan

Chapter 5 - Employee Information and Training

All laboratory researchers and their supervisors (Principal Investigators included) must be trained according to the requirements of the Laboratory Safety Standard. Colleges and non-academic departments that engage in the laboratory use of hazardous chemical, physical or biological agents are responsible for identifying such employees. The employees must be informed about their roles and responsibilities as outlined in this standard, as well as hazards associated with their work and how to work safely and mitigate those hazards.

DEHS provides web-based training modules on the basic information and training topics described below on the „Training" page of the DEHS website. At a minimum, new laboratory employees should complete the modules "Introduction to Research Safety", "Chemical Safety", and "Chemical Waste Management".

In addition, each laboratory supervisor is responsible for ensuring that laboratory employees are provided with training about the specific hazards present in their laboratory work area, and methods to control such hazards. Such training must be provided at the time of an employee's initial assignment to a work area and prior to assignments involving new potential exposures, and must be documented. Refresher training must be provided at least annually.

Volunteers conducting research in University laboratories, in addition to completing the training described below, must complete the Vol unt eer s an d V is it or"s La bor ator y Us e Agre em ent . If the volunteer is a minor, a parent or guardian must also sign the agreement. Because laboratories may contain hazardous chemicals, a minor who is paid to work in a research laboratory must obtain an exemption from the Minnesota Child Labor Act. An overview of this law is available on the web (http://www.dli.mn.gov/LS/Pdf/childlbr.pdf), as are Child Labor Exemption Applications (http://www.doli.state.mn.us/ls/Exemptions.asp) which should be completed by a parent, guardian or school official and filed with the Minnesota Department of Labor and Industry.

1. Information

It is essential that laboratory employees have access to information on the hazards of chemicals and procedures for working safely. Supervisors must ensure that laboratory employees are informed about and have access to the following information sources:

The contents of the OSHA Laboratory Safety Standard

> "Occupational Exposure to Hazardous Chemicals in Laboratories" and its appendices (29 CFR 1910.1450). A copy of this federal standard can be found in Appendix A of this Laboratory Safety Plan.

The University of Minnesota's Laboratory Safety Plan

> This generic LSP is available to all employees on the Department of Environmental Health and Safety's web site (http://www.dehs.umn.edu/ressafety_rsp.htm). Individual department Laboratory Safety Plans are available within those departments.

The Permissible Exposure Limits (PELs)

PELs for OSHA regulated substances can be found in Appendix B. Also included in Appendix B are the ACGIH Threshold Limit Value (TLV) list, a list of OSHA health hazard definitions, lists of "select carcinogens" and reproductive toxins, and chemicals having a high degree of acute toxicity.

Signs and symptoms associated with exposures to hazardous chemicals.

Laboratory Chemical Safety Summaries (LCSSs) are included on pages 235-413 of the 1995 edition of Prudent Practices (Prudent Practices in the Laboratory: Handling and Disposal of Chemicals). LCSSs are similar to Material Safety Data Sheets (MSDS), but are tailored to the hazards of laboratory use of those chemicals. The LCSSs include toxicity information, and signs and symptoms of exposure to the chemicals.

Material Safety Data Sheets (MSDSs)

MSDSs are available online through links from the Department of Environmental Health and Safety's web site. Hard copies of MSDS for many laboratory chemicals are also available from DEHS or departmental safety offices. Individual researchers are encouraged to keep hard copies in an easily accessible location for materials that are used in large quantities, which are used frequently, or which are particularly toxic.

Information on chemical waste disposal and spill response

The University of Minnesota guidebook, Hazardous Chemical Waste Management 5th edition provides detailed information on proper waste handling procedures.

2. Training

Employee training programs will include, at a minimum, the following subjects:

Methods of detecting the presence of hazardous chemicals;

Methods include visual observation, odor, real-time air monitoring, time-weighted air sampling, etc.

Basic toxicological principles;

Principles include toxicity, hazard, exposure, routes of entry, acute and chronic effects, dose-response relationship, LD50, threshold limit values and permissible exposure limits, exposure time, and health hazards related to classes of chemicals.

Prudent laboratory practices;

Prudent laboratory practices include general techniques designed to reduce personal exposure and to control physical hazards, as well as specific protective mechanisms and warning systems used in individual laboratories. Appropriate use of fume hoods is to be specifically addressed. As noted in Chapter 2, the text Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (National Research Council, 1995) describes general procedures to be followed in U of MN laboratories.

Description of available chemical information;

Container labels, Material Safety Data Sheets, etc.

Emergency response actions appropriate to individual laboratories;

Lists of emergency phone numbers, location of fire extinguishers, deluge showers, eyewashes, etc.

Applicable details of the departmental Laboratory Safety Plan;

Details should include general and laboratory-specific Standard Operating Procedures.

An introduction to the Hazardous Chemical Waste Management guidebook.

3. Updates

Update training is required for all laboratory researchers and supervisors / principal investigators (PI"s) at least annually. Departmental Research Safety Officers (RSOs) are responsible for coordinating and tracking update training. Often, RSOs may arrange for departmental-wide update-training sessions, focusing on results of laboratory audits, and highlighting issues that may need improvement. Videos from DEHS"s library may be borrowed to supplement these training sessions. Individual PI"s may conduct research-group-specific safety reviews to supplement or even stand in place of departmental update sessions. Documentation (paper or electronic) of all safety training must be maintained according to the requirements outlined in Chapter 10 of this Lab Safety Plan.

U of MN Characterization Facility

Laboratory Safety Plan

Chapter 6 - Required Approvals

„High hazard‟ research is that which due to the nature of the hazard, or the quantity of the material, or the potential for exposure poses higher than usual risk to the worker. Such research may require formal review and approval by a researcher‟s departmental safety committee, perhaps with involvement of DEHS personnel. High hazard research could include gases or chemicals listed in Tables 1-5 of this Laboratory Safety Plan, or certain biological or physical agents. RSOs should conduct laboratory audits and consult with Principal Investigators to identify research programs which may fall into this „high hazard‟ category.

PI‟s whose research is identified as „high hazard‟ should provide copies of their SOPs to the RSO and their department‟s safety committee for review and approval. The committee should respond with any comments or requests for changes in a timely manner, and keep a written record of approvals within the department.

U of MN Characterization Facility

Laboratory Safety Plan

Chapter 7 - Medical Consultation and Examination

1. Employees Who Work With Hazardous Substances

All employees who work with hazardous substances will have an opportunity to receive medical attention, including any follow-up visits that the examining physician determines to be necessary, under the following circumstances:

Signs or symptoms of exposure

> Whenever an employee develops signs or symptoms associated with a hazardous substance or organism to which the employee may have been exposed in the laboratory, the employee will be provided an opportunity to receive an appropriate medical examination.

Exposure monitoring

> 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 will be established for the affected employee as prescribed by the particular standard.

Exposure incident

> 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 will be provided an opportunity for a medical consultation. Such consultation will be for the purpose of determining the need for a medical examination.

Physical Injury

> Whenever an employee is physically hurt or injured on the job, the affected employee will be provided an opportunity for a medical consultation and/or examination. Physical injuries include but are not limited to cuts, burns, punctures and sprains.

Contact the Chemical Hygiene Officer whenever the need for medical consultation or examination occurs, or when there is uncertainty as to whether any of the above criteria have been met.

2. Medical Examinations and Consultations

In the event of a life-threatening illness or injury, dial 911 and request an ambulance. Employees with urgent, but non-life-threatening, illnesses or injuries should go to the nearest medical clinic. The University of Minnesota's Occupational Medicine Program is located in Boynton Health Service. If off-hours medical attention is required, the employee should be taken to the emergency room at Fairview University Medical Center's University campus. All medical examinations and consultations will be performed by or under the direct supervision of a licensed physician and will be provided without cost to the employee, without loss of pay and at a reasonable time and place.

3. Workers' Compensation Procedures and Forms

It is very important that even minor job-related injuries or illness are reported. These statistics help the Department of Environmental Health and Safety track trends that may indicate occupational hazards that need evaluation. To report an illness or injury, go to the W ork ers ' Com pens atio n website. University of Minnesota's Policy for Reporting Workers' Compensation Related Injuries is also available on the web. Both sites provide links to the forms listed below.

This policy explains the procedures and provides the necessary reporting forms. As long as the illness or injury is not life threatening, the supervisor should provide the employee with:

- ✓ a brochure describing Workers' Compensation Information for the University of Minnesota;
- ✓ a completed Employers' Authorization for Care form; and
- ✓ a Work Status Report for the physician to complete and return to the supervisor.

Within 24 hours, the supervisor should complete:

- ✓ a State of Minnesota First Report of Injury form;
- ✓ a U of MN Employee Incident Report form; and
- ✓ a U of MN Supervisor Incident Investigation Report.

Within 24 hours, supervisors must fax the State form to Sedgwick Claims Management Services at (952) 826-3785, and the U of MN forms to the University of Minnesota's Workers' Compensation Department (612)-627-1855.

4. Information Provided to Physician

The employee's supervisor or department will collect and transmit the following information to the examining physician:

- ✓ The identity of the hazardous substance(s) to which the employee may have been exposed;
- ✓ A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
- ✓ A description of the signs and symptoms of exposure that the employee is experiencing, if any.

5. Information Provided to the University of Minnesota

Supervisors should request that the examining physician provide them with a written report including the following:

- ✓ Any recommendation for further medical follow-up;
- ✓ The results of the medical examination and any associated tests;
- ✓ Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace; and
- ✓ 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.

The written opinion will not reveal specific findings of diagnoses unrelated to occupational exposure.

U of MN Characterization Facility Laboratory Safety Plan Chapter 8 - Personnel

The following individuals and groups have responsibilities for implementation of various aspects of the University of Minnesota's Laboratory Safety Plan.

Chemical Hygiene Officer

The University of Minnesota's Chemical Hygiene Officer is Dawn C. Errede, Department of Environmental Health and Safety. Ms. Errede is a Certified Industrial Hygienist (CIH) and chemical hygiene specialist with an M.S. in Environmental Health. Address: W-140 Boynton Health Service. Phone: 612-626-2330.

College or Departmental Research Safety Officer

The research safety officer for the Characterization Facility is Bing Luo. The specific duties of each safety officer will be determined at the college or departmental level. The duties of this RSO are included in Appendix K.

College or Departmental Safety Committee

The designation of a safety committee to assist the safety officer in his/her required duties is strongly encouraged. Names of the safety committee members should be listed in this paragraph.

Department of Environmental Health and Safety

The Department of Environmental Health and Safety offers assistance in a wide range of health and safety issues. Staff phone numbers are included in Appendix L. Address: W-140 Boynton. Phone: 612-626-6002.

Occupational Medicine Program

The University of Minnesota's Boynton Health Service provides occupational medicine services for the Research Occupational Health Program (ROHP) and the Respiratory Protection Program. For appointments, call the Boynton main appointment line at 612-625-3222 and ask to see the Occupational Physician. Non hospital employee chemical exposures should go through Boynton's urgent care.

U of MN Characterization Facility

Laboratory Safety Plan

Chapter 9 - Additional Employee Protection for Work with Particularly Hazardous Substances

Additional employee protection will be considered for work with particularly hazardous substances. These include select carcinogens, reproductive toxins and substances that have a high degree of acute toxicity (see Appendix B). Pp. 90-93 of the 1995 edition of Prudent Practices provides detailed recommendations for work with particularly hazardous substances. These pages may be accessed from DEHS's web site at www.dehs.umn.edu. Laboratory supervisors and principal investigators are responsible for assuring that laboratory procedures involving particularly hazardous chemicals have been evaluated for the level of employee protection required. Specific consideration will be given to the need for inclusion of the following provisions:

1. Planning;
2. Establishment of a designated area;
3. Access control
4. Special precautions such as:
   - use of containment devices such as fume hoods or glove boxes;
   - use of personal protective equipment;
   - isolation of contaminated equipment;
   - practicing good laboratory hygiene; and
   - prudent transportation of very toxic chemicals.
5. Planning for accidents and spills; and
6. Special storage and waste disposal practices.

U of MN Characterization Facility

Laboratory Safety Plan

Chapter 10 - Record Keeping, Review and Update of Laboratory Safety Plan

1. Record Keeping

Exposure evaluation

Any records of exposure evaluation carried out by individual departments (including continuous monitoring systems) will be kept within the department and also sent to the Department of Environmental Health and Safety. Results of exposure evaluations carried out by DEHS will be kept by DEHS and sent to the affected department. Raw data will be kept for one year and summary data for the term of employment plus 30 years.

Medical consultation and examination

Results of medical consultations and examinations will be kept by the Boynton Health Service for a length of time specified by the appropriate medical records standard. This time will be at least the term of employment plus 30 years as required by OSHA.

Training

Historically, individual employee training has been recorded on form BA 725A (see Appendix M) and kept in the individual's department or college for five years. More recently, web-based training and many in-person training sessions for employees are tracked electronically in the university"s PeopleSoft system. The records must include the name and title of the trainer, the trainee, the date and the content of training. Training records for laboratory volunteers must also be maintained for at least five years. Hard copy and/or electronic forms must be available in the event of an audit by the University Audit Department or state or county regulators.

Fume hood monitoring

Data on annual fume hood monitoring will be kept in the Department of Environmental Health and Safety. Fume hood monitoring data are considered maintenance records and as such the raw data will be kept for one year and summary data for 5 years.

Eyewash Records

Eyewash user logs should be kept on file for 1 year, because they are considered maintenance records.

Laboratory audits and reports

Research Safety Officers must coordinate and/or conduct formal audits of laboratories in their sphere of responsibility at least annually. A checklist is available in Appendix G, and a template report form is available in Appendix P. Checklists and reports should be kept for at least 5 years.

Accident investigation reports

Research Safety Officers work with PIs and researchers to complete the Accident Investigation Form in Appendix N. Reports should be kept for at least 5 years.

2. Review and Update of Laboratory Safety Plan

On an annual basis, this Laboratory Safety Plan will be reviewed and evaluated for effectiveness by the Department of Environmental Health and Safety and updated as necessary. Any changes in the Laboratory Safety Plan will be transmitted to college and departmental research safety officers, who are responsible for carrying out a similar review and modification of their plans, and submitting a revised copy to the Chemical Hygiene Officer.

U of MN Research Laboratory Safety Plan

Table 1 - 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	Boron trichloride	Chlorine pentafluoride
Chlorine trifluoride	Cyanogen	Cyanogen chloride
Diborane	Dinitrogen tetroxide	Fluorine
Germane	Hydrogen selenide	Nitric oxide
Nitrogen dioxide	Nitrogen trioxide	Nitrosyl chloride
Oxygen difluoride	Phosgene	Phosphine
Phosphorus pentafluoride	Selenium hexafluoride	Stibine
Sulfur tetrafluoride	Tellurium Hexafluoride	Tetraethyldithiopyrophosphate
Tetraethylpyrophosphate		

Guidance: Departments may choose to add other chemicals to the above list. For example, sulfur-containing compounds such as mercaptans can cause significant odor problems when used in the laboratory. Pre-approval of the conditions under which they can be used may prevent odor complaints.

U of MN Research Laboratory Safety Plan

Table 2 - 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.

- Acetylenic compounds, especially polyacetylenes, haloacetylenes, and heavy metal salts of acetylenes (copper, silver, and mercury salts are particularly sensitive)
- Acyl nitrates
- Alkyl nitrates, particularly polyol nitrates such as nitrocellulose and nitroglycerine
- Alkyl and acyl nitrites
- Amminemetal oxosalts: metal compounds with coordinated ammonia, 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, such as AgClO2 and Hg(ClO2)2
- Diazo compounds such as CH2N2
- Diazonium salts, when dry
- Fulminates such as 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 such as difluoroamino compounds and halogen azides
- N-Nitro compounds such as 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) that crystallize from or are left from evaporation of peroxidizable solvents (see the following Section 3)
- Peroxides, transition-metal salts
- Picrates, especially salts of transition and heavy metals, such as Ni, Pb, Hg, Cu, and Zn
- Polynitroalkyl compounds such as tetranitromethane and dinitroacetonitrile
- Polynitroaromatic compounds especially 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. Before purchasing this acid, laboratory supervisors must arrange for use of an approved perchloric acid hood. Please see the Perchloric Acid Fact Sheet for more information.

U of MN Research Laboratory Safety Plan

Table 3 - Pyrophoric Chemicals

The classes of chemicals listed below will readily oxidize and ignite spontaneously in air. Therefore, users must demonstrate to the department that they have the appropriate laboratory equipment, information, knowledge and training to use these compounds safely. Please see the Pyrophoric Chemicals Fact Sheet for further information.

- Grignard reagents, RMgX
- Metal alkyls and aryls, such as RLi, RNa, R_3Al, R_2Zn
- Metal carbonyls such as $Ni(CO)_4$, $Fe(CO)_5$, $Co_2(CO)_8$
- Alkali metals such as Na, K
- Metal powders, such as Al, Co, Fe, Mg, Mn, Pd, Pt, Ti, Sn, Zn, Zr
- Metal hydrides such as NaH, $LiAlH_4$
- Nonmetal hydrides, such as B_2H_6 and other boranes, PH_3, AsH_3
- Nonmetal alkyls, such as R_3B, R_3P, R_3As
- Phosphorus (white)

U of MN Research Laboratory Safety Plan

Table 4 - Peroxide-Forming Chemicals

The chemicals listed below can form explosive peroxide crystals on exposure to air, and therefore require special handling procedures after the container is opened. Some of the chemicals form peroxides that are violently explosive in concentrated solution or as solids, and therefore should never be evaporated to dryness. Others are polymerizable unsaturated compounds and can initiate a runaway, explosive polymerization reaction. All peroxidizable compounds should be stored away from heat and light. They should be protected from physical damage and ignition sources. A warning label should be affixed to all peroxidizable materials to indicate the date of receipt and the date the container was first opened. Due to these special handling requirements, users must have the appropriate laboratory equipment, information, knowledge and training to use these compounds safely.

A. Severe Peroxide Hazard with Exposure to Air (discard within 3 months from opening)

- diisopropyl ether (isopropyl ether)
- divinylacetylene (DVA)
- vinylidene chloride (1,1-dichloroethylene)
- potassium metal
- sodium amide (sodamide)
- potassium amide

B. Peroxide Hazard on Concentration

Do not distill or evaporate without first testing for the presence of peroxides (discard or test for peroxides after 6 months)

- acetaldehyde diethyl acetal (acetal)
- cumene (isopropylbenzene)
- cyclohexene
- cyclopentene
- decalin (decahydronaphthalene)
- diacetylene (butadiene)
- dicyclopentadiene
- diethyl ether (ether)
- diethylene glycol dimethyl ether (diglyme)
- dioxane
- ethylene glycol dimethyl ether (glyme)
- ethylene glycol ether acetates
- ethylene glycol monoethers (cellosolves)
- furan
- methylacetylene
- methylcyclopentane
- methyl isobutyl ketone
- tetrahydrofuran (THF)
- tetralin (tetrahydronaphthalene)
- vinyl ethers

C. Hazard of Rapid Polymerization Initiated by Internally-Formed Peroxides

Liquids (discard or test for peroxides after 6 months)

- Chloroprene (2-chloro-1, 3-butadiene)

- vinyl acetate
- styrene
- vinylpyridine

Gases (discard after 12 months)

- butadiene
- vinylacetylene (MVA)
- tetrafluoroethylene (TFE)
- vinyl chloride

U of MN Research Laboratory Safety Plan

Table 5 - Carcinogens, Reproductive Toxins or Highly Toxic Chemicals

The chemicals listed below are extremely hazardous. Workers must have knowledge of the dangers of these chemicals prior to use, and documentation of training in safe working procedures.

Biologically active compounds

- protease inhibitors (e.g. PMSF, Aprotin, Pepstatin A, Leopeptin);
- protein synthesis inhibitors (e.g. cycloheximide, Puromycin);
- transcriptional inhibitors (e.g. a-amanitin and actinomycin D);
- DNA synthesis inhibitors (e.g. hydroxyurea, nucleotide analogs (i.e.
- dideoxy nucleotides), actinomycin D, acidicolin);
- phosphatase inhibitors (e.g. okadaic acid);
- respiratory chain inhibitors (e.g. sodium azide);
- kinase inhibitors (e.g. NaF);
- mitogenic inhibitors (e.g. colcemid); and
- mitogenic compounds (e.g. concanavalin A).

Castor bean (Ricinus communis) lectin: Ricin A, Ricin B, RCA toxins

Diisopropyl fluorophosphate: highly toxic cholinesterase inhibitor; the antidote, atropine sulfate and 2-PAM (2-pyridinealdoxime methiodide) must be readily available

Jaquirity bean lectin (Abrus precatorius)

N-methyl-N'-nitro-N-nitrosoguanidine: carcinogen (this chemical forms explosive compounds upon degradation)

Phalloidin from Amanita Phalloides: used for staining actin filaments

Retinoids: potential human teratogens

Streptozotocin: potential human carcinogen

Urethane (ethyl carbamate): an anesthetic agent, potent carcinogen and strong teratogen, volatile at room temperature