George Mason University
Laboratory Safety Manual

Prepared by:
Environmental Health and Safety Office
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Table of Contents

List of Tables and Figures

Acronyms

AED	Automated external defibrillator
ABC	Virginia Department of Alcohol Beverage Control
AED	Automated External Defibrillator
ANSI	American National Standards Institute
APHIS	Animal and Plant Health Inspection Service
BLEVE	Boiling liquid expanding vapor explosion
BRL	Biomedical Research Laboratory
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
dBA	A-weighting Decibels
DEA	Drug Enforcement Agency
DEQ	Virginia Department of Environmental Quality
DNA	Deoxyribonucleic acid
DOT	U.S. Department of Transportation
EHS	Environmental Health and Safety Office
EPA	Environmental Protection Agency
fpm	Feet Per Minute
g	Gram
GHS	The Globally Harmonized System of Classification and Labelling of Chemicals
HBV	Hepatitis B Virus
HEPA	High Efficiency Particulate Air
IACUC	Institutional Animal Care and Use Committee
IARC	International Agency for Research on Cancer
IBC	Institutional Biosafety Committee
ICAO	International Civil Aviation Organization
IRB	Institutional Review Board
kg	Kilogram
LC	Lethal Concentration
LD	Lethal Dose

LS	Laboratory Supervisor
LSO	Laser Safety Officer
MAQ	Maximum Allowable Quantity
mg	Milligram
mm	Millimeter
MRI	Magnetic Resonance Imaging
MTA	Material Transfer Agreement
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
ORIA	Office of Research Integrity and Assurance
OSP	Office of Sponsored Programs
PAPR	Powered Air Purifying Respirator
PEL	Permissible Exposure Limit
PI	Principal Investigator
PLHCP	Physician or Other Licensed Healthcare Professional
PPE	Personal Protective Equipment
ppm	Parts Per Million
psi	Pounds per square inch
RO	Responsible Official
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SFPC	Statewide Fire Prevention Code
TLV	Threshold Limit Value
TTB	Alcohol and Tobacco Tax and Trade Bureau
TWA	Time Weighted Average
UL	Underwriters Laboratory, Inc.
UN	United Nations

Foreword

George Mason University is required under U.S. Code of Federal Regulations (CFR) Section 29, part 1910.1450 to provide a chemical hygiene plan that establishes minimum safety standards for working with chemicals in the laboratory and outlines procedures that minimize both the risk of chemical exposure to laboratory personnel and the risk of chemical releases into the environment. This *Laboratory Safety Manual* serves as the chemical hygiene plan for George Mason University and provides guidance on the safe handling of hazardous substances, general laboratory safety practices, and procedures for proper acquisition, use, storage, transfer, and disposal of chemicals. The recommendations and requirements provided in this manual are based on guidance from regulatory agencies and current professional standards. George Mason University's Chemical Hygiene Officer oversees the development and implementation of George Mason University's Chemical Hygiene Program.

A current version of the *Laboratory Safety Manual* must be available in each research and instructional laboratory, and laboratory personnel must be familiar with the contents of this manual. The *Laboratory Safety Manual* is reviewed annually by the Environmental Health and Safety Office (EHS) and revised as necessary to reflect changes in the Laboratory Safety Program, George Mason University policies, and government regulations. This and other manuals, guides, plans, and forms are available on the EHS website (ehs.gmu.edu).

This *Laboratory Safety Manual* supersedes all previous *Laboratory Safety Manuals* at George Mason University.

Document History

Version	Date	Comments
1	July, 2006	Initial *Laboratory Safety Manual*
2	November, 2007	Routine review and update
3	December, 2009	Routine review and update
4	October, 2013	Routine review and update

1.0 Introduction

Instructional and research laboratories contain hazards that must be properly managed in order to minimize the risk they pose to health, safety, and the environment. These hazards include exposure to hazardous substances (e.g., chemicals, biological materials, and radioactive materials) and physical hazards associated with chemicals, equipment, and instruments used by laboratory personnel.

1.1 Hazardous Substances

The term *hazardous substance*, as used in this manual, refers to any material that may present a danger to human health and welfare or the environment. This includes hazardous chemicals (e.g., laboratory chemicals, pesticides, and petroleum products), biohazardous materials (infectious materials), and radioactive materials.

A *hazardous chemical*, as defined by the Occupational Safety and Health Administration (OSHA), is a chemical "which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified." Most chemicals used in the laboratory are hazardous.

Particularly Hazardous Substances are a subset of hazardous chemicals that require special consideration and additional safety provisions, because of their toxic effects. Select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity are particularly hazardous substances. More information about these substances is provided throughout this manual.

1.2 Regulations, Guidelines, and Permit Requirements

The following agencies regulate laboratory activities and provide guidance and direction concerning the use of chemicals in the laboratory.

The Occupational Safety and Health Administration (OSHA) develops and enforces regulations based on federal statutes. OSHA regulates health and safety in the workplace, establishes chemical exposure limits, and sets minimum standards for work place health and safety (www.osha.gov).

The Environmental Protection Agency (EPA) develops and enforces environmental regulations to protect human health and the environment. The EPA regulates hazardous waste, machinery emissions, waste water, storm water, and other hazardous materials in an effort to reduce their impact on the environment (www.epa.gov).

The National Institute for Occupational Safety and Health (NIOSH) is a research division of the Centers for Disease Control and Prevention (CDC) created by the Occupational Safety and Health Act of 1970. NIOSH conducts research, makes recommendations for the prevention of work related illness, and publishes sources of chemical toxicity information (www.cdc.gov/niosh).

The National Fire Protection Association (NFPA) provides codes and standards for fire safety, chemical storage, egress, and laboratory engineering controls for laboratories using chemicals (www.nfpa.org).

The United States Department of Transportation (DOT) regulates packaging, shipping, and documentation of hazardous materials during transportation and distribution including shipping and receiving (www.dot.gov).

The Virginia Department of Environmental Quality (DEQ) develops and enforces environmental regulations in the Commonwealth of Virginia. DEQ has the ability to enforce environmental regulations equivalent to or more stringent than those instituted by the federal government (www.deq.virginia.gov).

2.0 Roles and Responsibilities

It is the responsibility of all employees, affiliates, students, and visitors to conduct laboratory work and activities in a manner that will not adversely impact themselves, other laboratory personnel, George Mason University property, the surrounding community, or the environment (University Policy Number 1406). The implementation of a comprehensive laboratory safety program relies on the complete support and cooperation of various university entities including the University President, Vice President for Research and Economic Development, EHS, the Office of Sponsored Programs (OSP), the Office of Research Integrity and Assurance (ORIA), Student Health Services, various safety committees, deans, directors, department chairs, Unit Safety Liaisons, Principal Investigators (PI), Laboratory Supervisors (LS), and laboratory personnel. Specific responsibilities are outlined below.

2.1 University President

The President acts as Chief Executive Officer of George Mason University and has general responsibility for the direction and supervision of George Mason University and its academic and administrative units. OSHA has determined that the Chief Executive Officer is ultimately responsible for chemical hygiene within an institution (29 CFR 1910); therefore, the President has ultimate responsibility for laboratory and environmental health and safety at George Mason University.

2.1.1 Vice President for Research and Economic Development

The President delegates authority to the Vice President for Research and Economic Development, who is charged with overseeing all aspects of laboratory compliance with regard to health and safety. Specific responsibilities are to:

- Approve and oversee all plans, policies, and procedures related to laboratory compliance with regard to environmental health and safety for instructional and research laboratories at George Mason University.
- Oversee EHS.
- Serve as the Certifying Officer for the Radiation Safety Program.
- Appoint members to the Institutional Biosafety Committee (IBC) and the Radiation Safety Committee (RSC).
- Appoint Responsible Official (RO) and Alternate Responsible Official to oversee the Select Agent Program.
- Appoint, in consultation with the Director of the Krasnow Institute and the Chair of Neuroengineering Core of Krasnow Institute, the Magnetic Resonance Imaging (MRI) Safety Manager.
- When necessary, enforce sanctions regarding laboratory noncompliance, as recommended by the IBC, RSC, or EHS.

2.1.2 Environmental Health and Safety Office (EHS)

EHS collaborates with the university community to promote health, safety, environmental protection, emergency preparedness and compliance with applicable regulations, guidelines, and

best practices in order to sustain a healthful and safe working and learning environment. This mission is accomplished by establishing policies and procedures, providing training and education, facilitating emergency management, implementing preventive actions, and ensuring continuous improvement of Mason's health and safety programs for employees, students, and visitors. The EHS Laboratory Safety Program provides services to assist laboratories in meeting regulatory requirements and minimizing the risks associated with laboratory hazards. Specific responsibilities with regard to laboratories are to:

- Maintain current knowledge of laboratory safety regulations and guidelines.
- Develop and administer plans, policies, and procedures that meet safety and regulatory compliance requirements for laboratories.
- Provide technical guidance in the development of policies and procedures regarding laboratory safety.
- Provide adequate and appropriate training in laboratory safety to personnel, commensurate with the duties they perform.
- Conduct exposure monitoring of laboratory spaces as warranted.
- Conduct routine laboratory inspections to assure compliance with laboratory safety policies and procedures.
- Oversee laboratory waste management.
- Serve as the primary point of contact with local, state, and federal officials regarding applicable regulations and reporting requirements in the area of laboratory safety.
- Provide technical assistance in all matters of laboratory safety, and assist laboratory personnel with the evaluation and control of laboratory hazards and regulatory compliance.
- Maintain records and documentation in accordance with local, state, and federal regulations; and George Mason University policies and procedures.
- Coordinate activities of the IBC and RSC to include review of projects involving biological and radiological materials and implementation of corrective actions.
- Work closely with ORIA, the Institutional Animal Care and Use Committee (IACUC), and the Institutional Review Board (IRB) on Mason policy and regulatory compliance regarding laboratory hazards.
- Work closely with Facilities Administration regarding construction and renovation of laboratory facilities.
- Approve renovation of existing laboratory spaces and alteration of a work space to or from a laboratory.
- Evaluate work area designs to determine suitability of a space for proposed work.
- Coordinate with Unit Safety Liaisons.
- Manage safety equipment testing and certification to include Automated External Defibrillators (AED), fire extinguishers, emergency showers and eyewashes, chemical fume hoods, and biosafety cabinets.
- Provide spill supplies and first aid kits to laboratories.
- Execute authority to order remedial action or to temporarily or permanently suspend the right to operate an instructional and research laboratory when immediate or significant hazards present a danger to health, the environment, or property at George Mason University.

2.1.2.1 Chemical Hygiene Officer

The Chemical Hygiene Officer administers George Mason University's Chemical Hygiene Program. Specific responsibilities are to:

- Provide technical guidance in the development of policies and procedures regarding chemical safety.
- Inspect laboratories to monitor compliance with laboratory safety policies and procedures.
- Provide general chemical safety training (and laboratory-specific training upon request).
- Maintain current knowledge of laboratory safety regulations and guidelines.
- Assist PI/LS in evaluating and controlling laboratory hazards.
- Implement corrective actions as necessary.
- Manage hazardous waste generated in instructional and research laboratories.
- Continually evaluate and improve the university's Chemical Hygiene Program.
- Serve as a Hazardous Materials Emergency Coordinator for George Mason University.

2.1.2.2 Biological Safety Officer (BSO)

The BSO administers the Biological Safety Program for laboratories operating at biosafety level (BSL) 1 and 2, and supports the Biosafety Manager for the Biomedical Research Laboratory (BRL). Specific responsibilities are to:

- Provide technical guidance in the development of policies and procedures regarding the use of biological materials in laboratories.
- Provide training on the hazards associated with biological materials in the workplace and appropriate measures to reduce the risk posed by these hazards.
- Inspect biological laboratories to assist in compliance with laboratory safety policies and procedures.
- Assist PI/LS in evaluating and controlling biohazards.
- Oversee management of biological waste, serve as a Waste Management Facility Operator for the Prince William and Fairfax campuses, and as the primary point of contact with the DEQ regarding regulated medical waste.
- Coordinate activities of the IBC, and serve as primary point of contact with the Office of Biotechnology Activities.
- Oversee certification of biosafety cabinets.
- Serve as a member of the George Mason University's IACUC.

2.1.2.3 Biosafety Manager for the Biomedical Research Laboratory (BRL)

The Biosafety Manager for the BRL oversees biosafety, biosecurity, and the Select Agent Program for work conducted in the BRL. Specific responsibilities are to:

- Provide technical guidance in the development of policies and procedures regarding the use of select agents and toxins at BSL-3.

- Serve as the RO for the Select Agent Program and serve as the primary point of contact with the CDC/Animal and Plant Health Inspection Service (APHIS) regarding select agent registration.
- Administer the BRL Training Program.
- Conduct routine laboratory inspections to assure compliance with laboratory safety policies and procedures and select agent program requirements.
- Assist PI/LS in evaluating and controlling biohazards.
- Serve as member of IBC.
- Serve as member of the BRL Management Team.

2.1.2.4 Radiation Safety Officer (RSO)

The RSO administers the university's Radiation Safety Program. Specific responsibilities are to:

- Maintain current knowledge of laboratory safety regulations and guidelines.
- Provide technical guidance in the development of policies and procedures regarding radiation safety.
- Inspect radiation laboratories to monitor compliance with laboratory safety policies and procedures.
- Provide general radiation training for laboratory personnel (and laboratory-specific training upon request).
- Serve as member of RSC and coordinate RSC activities.
- Assist PI/LS in evaluating and controlling radiation hazards.
- Implement corrective actions as necessary.
- Manage radioactive waste generated in instructional and research laboratories.
- Notify ORIA of any projects which may include the use of animals or human subjects.
- Serve as the university's point of contact with the Virginia Department of Health.
- Continually evaluate and improve the university's Radiation Safety Program.

2.1.2.5 Laser Safety Officer (LSO)

The LSO administers the George Mason University's Laser Safety Program. Specific responsibilities are to:

- Establish and maintain policies and procedures for the safe use of lasers.
- Classify lasers or verify the hazard class of lasers.
- Perform hazard evaluation of laser work areas.
- Specify control measures and assure implementation.
- Approve laser systems operation and procedures for maintenance and use of lasers.
- Assure adequate training of laser personnel.
- Maintain records for the Laser Safety Program.
- Perform periodic audits of the Laser Safety Program.
- Serve as lead investigator for accidents involving lasers.

2.1.2.6 Occupational Health and Safety Personnel

The Occupational Health and Safety group within EHS is responsible for supporting EHS-Laboratory Safety personnel in providing a safe and healthful laboratory environment. In addition to the specific responsibilities with regard to laboratory safety outlined below, the Director of Occupational Health and Safety serves as members of IBC and IACUC.

- Provide technical guidance in the development of policies and procedures regarding laboratory safety.
- Provide *Bloodborne Pathogens Safety Training* and *Respiratory Protection Training* to laboratory personnel.
- Administer the *Medical Surveillance Plan* for laboratory personnel to include, but not limited to, approving laboratory personnel for vaccination based on risk; selecting respiratory protection equipment and performing fit tests when needed; and initiating the *Animal Handler Questionnaire*.
- Coordinate with a physician or other licensed healthcare professional (PLHCP) to provide medical surveillance to laboratory personnel.
- Conduct exposure monitoring when necessary or upon request.
- Conduct root-cause analysis following laboratory and research animal-related injuries and accidents.

2.1.2.7 Magnetic Resonance Imaging (MRI) Safety Manager

The MRI Safety Manager and Technologist administers the MRI Safety Program. Specific responsibilities are to:

- Provide technical guidance in the development of policies and procedures regarding MRI safety.
- Maintain appropriate certifications to include American Registry of Radiologic Technologists certification and Basic Life Support.
- Serve as ex-officio member of Neuroimaging Core of the Krasnow Institute of Advanced Study.
- Implement the MRI Safety Program and require compliance with all relevant policies, procedures, and regulatory requirements regarding MRI safety and operations.
- Administer MRI training for George Mason University personnel.
- Oversee service and maintenance for the MRI suite and coordinate with service engineers as necessary regarding service and maintenance.
- Coordinate monthly and expedited reviews for incidental findings.
- Oversee scheduling and maintain calendar for the MRI scanner.
- Maintain documentation and records.
- Cease or suspend unsafe activities and instances of noncompliance until the issues can be resolved and corrective actions taken.
- Report unsafe activities and issues of noncompliance to the Director of Laboratory Safety and the Director of the Krasnow Institute.

- Conduct safety screening of all users of the MRI suite as a component of MRI safety training and approve or deny access to the suite based on training proficiency and screening results.
- Respond to incidents and emergencies as needed during and after normal work hours.
- Supervise the part-time MRI Technologist(s).

2.1.3 Office of Sponsored Programs (OSP)

OSP is the pre-award and post-award office for all externally-sponsored projects at George Mason University. OSP provides assistance in proposal budget development and proposal submission. OSP also reviews and signs all proposals to external sponsors. All contracts with George Mason University, which involve sponsored projects, are reviewed, negotiated, and executed by OSP. Specific responsibilities are to:

- Notify EHS of awarded projects that involve laboratory hazards, as indicated on the *Proposal Approval Routing Form* (available on the OSP website).
- Include in all contractual agreements with other entities requirements for compliance with university, local, state, and federal rules and regulations for hazardous substances.
- Notify EHS of all Material Transfer Agreements (MTA) involving hazardous substances.

2.1.4 Office of Research Integrity and Assurance (ORIA)

ORIA handles the administrative management for research with human subjects and the care and use of animals in research. This office also supports the IRB, formerly the Human Subjects Review Board, and the IACUC. Specific responsibilities of ORIA are to:

- Work with EHS and relevant safety committees on university policy and regulatory compliance regarding laboratory hazards.
- Notify EHS of any IRB or IACUC protocols, which may include use of laboratory hazards.

2.1.5 Student Health Services

Student Health Services offers confidential health services that include components of diagnosis, treatment, self-care, health promotion, and disease prevention. The goal of Student Health Services is to provide all currently-enrolled students with high-quality health care. In addition, Student Health Services provides professional consultation in the event of potentially hazardous exposures and administers various vaccinations to faculty, staff, and students as medically indicated.

2.1.6 University Police

University Police play a crucial role in protecting life and property at George Mason University. In addition to being George Mason University's first responder to any emergency, they establish and maintain crowd control, scene security, and law and order in the event of an emergency. University Police initiate mutual aid agreements with law enforcement agencies and other emergency service support providers for all campuses. In coordination with EHS and other

departments, University Police develop and promulgate procedures to respond to civil disturbances, bomb threats, and other potential threats to campus safety and security. Additionally, individual police officers are encouraged to report unsafe conditions when observed.

2.1.7 Waste Management Facility Operator

George Mason University is required by DEQ to have Waste Management Facility Operators on staff for each campus where autoclaves are used to treat biohazardous waste. Currently, Mason has Waste Management Facility Operators at the Fairfax and Prince William campuses whose responsibility is to verify compliance with DEQ regulations. A complete list of responsibilities is provided in the *Biological Safety Manual*.

2.1.8 Safety Review Committees

The IBC and RSC are comprised of George Mason University faculty, staff, and affiliates, and serve as safety review committees for research and instructional projects that involve biological materials or sources of radiation. Specific responsibilities are to:

- Provide guidance and recommendations to the Vice President for Research and Economic Development and EHS on policies and procedures regarding instructional and research projects involving laboratory hazards.
- Review reports from EHS on unsafe practices and safety hazards in the laboratory and make recommendations on corrective actions regarding these hazards to the Vice President for Research and Economic Development.
- Recommend appropriate sanctions to temporarily or permanently suspend the right to operate in instructional and research laboratories, or determine other actions necessary to deal with noncompliance. However, at times it may be necessary for EHS to suspend the right to operate in instructional and research laboratories or to take some other action necessary to deal with noncompliance prior to the involvement of a safety review committee.
- Adhere to additional responsibilities as outlined in their respective charters.

2.1.9 Deans or Directors

Each Dean or Director has the responsibility for overseeing all instructional and research laboratory work and activities in their unit. Deans and Directors may delegate these responsibilities to departmental chairpersons. Specific responsibilities are to:

- Implement and comply with George Mason University laboratory safety policies and procedures.
- Inform employees, affiliates, students, and volunteers in their units of George Mason University laboratory safety policies and procedures.
- Report instances of noncompliance (failure to exercise and implement laboratory safety policies and procedures) in their units to the Director of Laboratory Safety.
- Designate a faculty member from their unit to serve as Unit Safety Liaison. Unit Safety Liaisons should be chosen based on their ability to convey information quickly and

efficiently between EHS and their unit and they should have direct access to the Dean, Director, or Department Chairperson on important laboratory safety, health, and environmental issues.

- Designate a faculty member or staff person to be responsible for laboratory and environmental health and safety for each laboratory and laboratory support space in their unit. In research laboratories, most often, this person is the PI responsible for the research being done in that laboratory. For instructional laboratories and support spaces, this person may be the LS responsible for coordinating and preparing for laboratory courses in that laboratory.
- Provide necessary resources for safety-related items [e.g., Personal Protective Equipment (PPE) for instructional courses, flushing emergency showers and eye washes, etc.].
- Sign Project Review Form approval letters as necessary to acknowledge the commencement or continuation of research and instructional projects in their unit.

2.1.10 Unit Safety Liaisons

Unit Safety Liaisons play an important role in coordinating with EHS on laboratory and environmental health and safety efforts in their unit so that adequate services are provided and effective relationships are established. All units are required to appoint a Unit Safety Liaison to oversee the development and implementation safety and emergency programs. Unit Safety Liaisons are appointed by Vice Presidents, Deans, Directors, Academic Heads, and Department Heads. The Unit Safety Liaison must be a faculty or staff person with authority to direct personnel within the unit and to commit resources as necessary to resolve safety issues and manage an emergency situation and. Specific responsibilities of Unit Safety Liaisons are to:

- Serve as a central point of contact between EHS and your unit for the dissemination and gathering of information. Examples include fire safety inspection reports, emergency plans, unsafe work conditions, and work orders pertaining to environmental health and safety issues.
- Recruit, appoint, and oversee Unit Building Coordinator(s), Unit Floor Coordinator(s), and AED Coordinator(s) as appropriate based upon the unit's organizational structure.
- Oversee the completion and maintenance of emergency preparedness guides and compile them in a university safety manual (provided by EHS).
- Periodically review guides with faculty, staff, and students to ensure that those who may be affected are familiar with their content and location of safety and emergency procedures.
- Assist faculty and staff in identifying work area hazards and make recommendations for improving safety within the unit.
- Report safety and occupational health concerns to EHS.
- In the absence of a designated AED Coordinator, serve in this capacity.
- Communicate building disruptions to occupants, Building Coordinators and Floor Coordinators.
- During a building evacuation, drill, or emergency:
    - Direct Unit Building and Floor Coordinator(s) to clear their assigned area to facilitate an evacuation in a timely fashion.

    - Assist persons with a disability as needed to an area of rescue or evacuate the building. If they are unable to evacuate, notify University Police of their location.
    - Coordinate with Building and Floor Coordinator(s) once outside to account for occupants of the workspace and/or building.
- During an emergency:
    - Contact University Police to report an emergency situation.
    - If safety permits, notify the appropriate Unit Building Coordinator(s) in an emergency and direct them to respond as appropriate.
    - Assist students, faculty, and staff in an emergency as appropriate when safe to do so (e.g., communicate emergencies, assist in evacuation, or initiate shelter-in-place).
    - During an emergency, note any hazards or pertinent information and relay it to emergency response personnel (e.g. location of the emergency, cause, injuries, or people waiting for rescue in an area of assistance).
    - Serve as the unit's primary on-scene contact for university emergency management personnel and first responders.

For units that maintain laboratories, the Unit Safety Liaison is also responsible for:

- Assisting the unit/department in resolving laboratory inspection deficiencies.
- Providing EHS updates and information regarding laboratory moves.
- Overseeing biweekly flushing of emergency shower and eyewashes.
- Often the Unit Safety Liaison will also serve as a point of contact for PPE (i.e., lab coat laundering contract, selection of eye protection).

For more information on the role of Unit Safety Liaison Program, visit the EHS website.

2.1.11 Principal Investigator or Laboratory Supervisor (PI/LS)

PI/LS are responsible for overseeing all laboratory work, activities, and employees in their laboratory. It is the responsibility of the PI/LS to assure that George Mason University laboratory safety policies and procedures and good safety practices are followed, applicable safety regulations are considered, appropriate safety equipment is made available, and necessary safety training is completed. PI/LS who oversee research or instructional laboratories must attend safety training in order to become familiar with the Laboratory Safety Program at the university. Specific responsibilities are to:

- Provide information to all laboratory personnel regarding hazardous substances and other laboratory hazards. Instruct personnel in safe laboratory practices and procedures for dealing with these hazards.
- Acquire the knowledge and information needed to perform risk assessments and recognize and control hazards in their laboratory. All risk assessments should be reviewed at least annually.
- Plan adequately for experiments to reduce the likelihood of exposure to hazardous conditions and substances.

- Develop written laboratory safety policies and procedures specific to the work and activities performed in their laboratory based on risk assessments, including a *Supplemental Laboratory Safety Plan*.
- Provide training in the following areas to all laboratory personnel and maintain written documentation of this training:
    - Laboratory-specific hazards and safety policies, procedures, and equipment;
    - Location and use of Safety Data Sheets (SDS);
    - Proper storage, handling, and disposal of hazardous materials and waste;
    - Laboratory-specific emergency procedures, contact information, evacuation procedures, and the location(s) and use of spill supplies;
    - Location, use, storage, and maintenance of PPE;
    - Location and use of George Mason University laboratory safety documents and the responsibilities of laboratory personnel; and
    - Access restrictions and the need to challenge unknown persons entering the laboratory.
- Submit a *Project Review Form* for all instructional and research projects involving biological materials or ionizing radiation prior to their commencement and update these forms as necessary.
- Register all class 3b and 4 lasers with the Laser Safety Officer.
- For all instructional and research project proposals, correctly complete the "Laboratory Hazards" section of the OSP *Proposal Approval Routing Form*.
- Review and approve new laboratory projects, tests, or procedures involving Particularly Hazardous Substances before they are initiated by laboratory personnel.
- Implement appropriate security precautions to prevent unauthorized individuals from gaining access to laboratory materials and equipment.
- Implement appropriate access restrictions and requirements for visitors, volunteers, and minors.
- Implement signage and labeling requirements.
- Maintain required laboratory safety records to include accurate inventory records.
- Contact EHS if it is determined or suspected that an exposure has occurred.
- Work closely with Facilities Management and EHS to select, acquire, and install appropriate engineering controls prior to the commencement of the work that requires these controls.
- Work closely with EHS so that safety equipment is available, routinely inspected, and repaired or replaced as necessary.
- Provide all laboratory equipment necessary to safely perform procedures and adequately maintain equipment through routine maintenance, testing, and calibration.
- Provide, maintain, and replace PPE worn by laboratory personnel.
- Implement storage requirements for hazardous substances.
- Implement practices and procedures designed to minimize or eliminate exposure to laboratory hazards.
- Adhere to shipping and transportation requirements for hazardous materials.
- Properly manage laboratory waste.
- Follow laboratory close-out procedures when leaving George Mason University, relocating, closing, or renovating a laboratory.

- Maintain spill supplies and contact EHS when additional supplies are needed.
- Communicate instances of spills, accidents, near-accidents, and unsafe work conditions to EHS.
- If using sources of ionizing radiation, follow additional responsibilities as outlined in the *Radiation Protection Plan*.
- If using biological materials, follow additional responsibilities as outlined in the *Biological Safety Manual*.
- Coordinate as necessary with other entities listed in this manual to optimize safety within the laboratory.
- Adhere to additional responsibilities for laboratory personnel.

2.1.12 Laboratory Personnel

It is the responsibility of all laboratory personnel to conduct laboratory work and activities in a manner that will not adversely impact themselves, other laboratory personnel, the surrounding community, or the environment. Specific responsibilities are to:

- Follow George Mason University policies, procedures, recommendations, and requirements for laboratory safety as stated by their PI/LS and EHS.
- Complete all required laboratory safety training.
- Seek approval from the PI/LS for all work involving hazardous substances.
- Be knowledgeable of the following:
    - *Laboratory Safety Manual* and *Supplemental Laboratory Safety Plan*;
    - Location and use of *SDS Library*;
    - Proper storage, handling, and disposal of hazardous substances;
    - Laboratory-specific emergency procedures, contact information, evacuation procedures, and the location(s) and use of spill supplies;
    - Location, use, storage, and maintenance of PPE;
    - Location and use of the appropriate George Mason University laboratory safety manuals;
    - Access restrictions and the need to challenge unknown persons entering the laboratory; and
    - Location and use of fire safety equipment.
- Develop good chemical hygiene habits.
- Communicate instances of spills, accidents, near-miss accidents, and unsafe work conditions to PI/LS and EHS.
- Communicate instances of known or suspected exposures to PI/LS and EHS.

2.2 Employee Rights

The Occupational Safety and Health Act of 1970 provides rights to employees that offer protection from hazards in the workplace. OSHA publication 3021-08R 2003 *Employee Workplace Rights* lists and discusses these rights in detail. A summary of these rights is provided below. Personnel at George Mason University have the right to:

- Review copies of appropriate standards, rules, regulations, and requirements that George Mason University is required to have available at the workplace.
- Know the identity of safety and health hazards encountered at the workplace.
- Request information from the employer on safety and health hazards in the work place, appropriate precautions to take, and procedures to follow if the employee is involved in an accident or exposure.
- Receive appropriate training before beginning work with hazardous substances.
- Receive training when a new hazard is introduced into the workplace.
- Gain access to relevant employee exposure and medical records.
- Review or have an authorized representative review the employer's Log of Work-Related Occupational Injuries and Illnesses (OSHA 300) at a reasonable time and in a reasonable manner.
- Refuse to perform unsafe work that presents imminent danger of death or serious injury.
- Refuse to work with a hazardous substance if information about it is not provided within five working days after filing a written request with the PI/LS or if proper safety equipment or safety guards are not provided.
- Receive medical attention and treatment in the event of an exposure to a hazardous substance or laboratory injury.
- File a written complaint/request with OSHA and to request anonymity, without repercussions from George Mason University.
- Protection against discharge, discipline, or discrimination as a result of exercising any of the above rights.

3.0 Assessment and Management of Risk

Accurate assessment of the risks associated with laboratory operations and the implementation of measures to effectively manage those risks are critical components of laboratory safety. In the context of research and instructional laboratories, risk assessment focuses primarily on the prevention of laboratory-associated exposure to physical, chemical, biological, and radiation hazards. Risk management is the application of appropriate administrative, engineering, and personal protective equipment to reduce the potential for accidental exposure or release to the environment.

The assessment and management of risk is an ongoing process and must be continually evaluated to reflect changes in the quantity or type of hazardous substances present in the laboratory, types of procedures to be performed, and current regulations and recommendations from government agencies regarding safe laboratory practices.

3.1 Risk Assessment

PI/LS should perform risk assessments that consider the types of hazards present in the laboratory, the risk of exposure to laboratory personnel, and the type of work to be performed. Prudent planning is a critical component of risk assessment. The following factors should be considered when determining the risk associated with a particular project or procedure:

- Hazards associated with the procedure;
- Potential for a harmful personal exposure to occur;
- Potential for release of a hazardous substance to the environment;
- Level of training and experience of personnel;
- Use and condition of laboratory equipment;
- Availability of safety equipment such as chemical fume hoods and/or biosafety cabinets;
- Appropriate PPE;
- Type and volume of hazardous substances used and waste generated;
- Proper storage;
- Potential for production of harmful byproducts; and
- Appropriate response procedures in the event of an emergency.

Exposure to hazardous substances can occur through inhalation, ingestion, contact with or absorption through skin or mucous membranes, or through parenteral injury. When evaluating laboratory procedures, PI/LS should consider likely routes of exposure for the hazardous substances used in the laboratory, safety precautions and equipment (such as PPE and chemical fume hoods) that can be utilized to minimize the risk of exposure, and exposure response procedures to be implemented in the event of an exposure.

Risk of injury due to physical hazards (e.g., thermal, electrical, mechanical) should also be evaluated. Attention should be given to the location of physical hazards and the availability of proper safeguards. In addition, good housekeeping practices and routine equipment maintenance

should be implemented to prevent injuries resulting from trip hazards, frayed wires, malfunctioning equipment, or damaged instruments.

EHS can assist PI/LS in accurately assessing laboratory risks and in devising appropriate management strategies to minimize those risks.

3.2 Risk Management

Risk management involves the use of measures designed to reduce potential exposure of laboratory personnel, the community, and the environment to hazards present in the laboratory. A comprehensive risk management program includes administrative, engineering, and physical controls that reduce the duration, frequency, and severity of exposure to laboratory hazards. Administrative controls include written safety procedures and practices, training, documentation, access restrictions, and proper signage and labeling. Engineering controls include facility features such as laboratory design, ventilation systems, storage areas, and safety equipment. Physical controls are provided by PPE and good chemical hygiene practices. Controls applicable to research and instructional laboratories are discussed in the remaining sections of this manual.

3.3 Supplemental Laboratory Safety Plan

OSHA requires that all laboratories have a written plan to protect personnel from hazards present in the laboratory. To meet this requirement, each laboratory is required to have a *Supplemental Laboratory Safety Plan* that serves as a supplement to the *Laboratory Safety Manual* and provides specific information about the types of hazards present in the laboratory and outlines laboratory-specific administrative and engineering controls, PPE, operational procedures (e.g., decontamination, waste handling), and procedures for spill or exposure response. The plan must include written safety procedures for work involving Particularly Hazardous Substances, infectious material, animals, and certain types of specialized equipment.

To facilitate compliance with this requirement, EHS has developed a *Supplemental Laboratory Safety Plan* template (available on the EHS website). The plan must be submitted electronically to EHS, must be kept in the *Safety Records and Resources* binder in each laboratory where it is easily accessible to laboratory personnel, and must be routinely reviewed and evaluated to assure information is both current and accurate. Laboratory personnel must receive training on the *Supplemental Laboratory Safety Plan* upon beginning work in the laboratory and anytime there are significant changes to the plan. A *Laboratory Training Signature Page* (available on the EHS website) verifying receipt of this training must be kept with the plan in the *Safety Records and Resources* binder.

4.0 Engineering Controls

Engineering controls are facility features and equipment intended to reduce the likelihood or severity of an exposure. This includes laboratory design, safety equipment, and safety guards on laboratory equipment. PI/LS should consult with Facilities Management and EHS to select, acquire, and install appropriate engineering controls prior to the commencement of the work that requires these controls. This information should be considered when designing a new laboratory or renovating an existing laboratory facility.

4.1 Laboratory Design

Appropriate design and traffic flow is critical to the development of a safe work environment for laboratory personnel. In the following sections, several considerations for facility design are discussed. This information is useful for designing a new laboratory or renovating existing laboratory facilities.

4.1.1 Laboratory Ventilation

Based on OSHA recommendations, EHS requires the air exchange rate for laboratories between six and 12 air changes per hour, depending on laboratory activities. Laboratory ventilation systems are designed to be single-pass systems that support a negative pressure environment with respect to adjacent hallways and rooms. Building air intake and exhaust vents are situated to prevent recirculation of laboratory exhaust. For additional information reference the *Laboratory Ventilation Management Plan*.

All modifications to laboratory heating, ventilation, and air conditioning systems must be approved by EHS. Once modifications have been made to laboratory systems, chemical fume hood evaluations must be conducted, and the room air changes per hour must be calculated and modified, as necessary, to meet ventilation standards.

4.1.2 Fire Safety

All laboratories should meet the requirements of NFPA-45 *Standard on Fire Protection for Laboratories Using Chemicals*. These requirements include the following:

- Passageways and aisles must be a minimum of 36 inches wide and must remain unobstructed.
- The location of emergency exits for each laboratory and laboratory support room must be clearly marked. If possible, there should be two exits for each laboratory area.
- Exits, stairs, and passageways should be permanently illuminated to facilitate evacuation in the event of an emergency. Emergency exits must be clearly marked.
- Fire doors must remain unobstructed.
- Flammable chemicals must be stored as outlined in Section 9.0.

4.1.3 Lighting

Laboratories should be equipped with adequate glare-free lighting. For typical laboratory work, National Institutes of Health (NIH) recommends 75-120 foot-candles of illumination. Specific laboratory activities may require unique lighting strategies such as explosion-proof lighting or infrared lighting to prevent potential fires and to protect the work being conducted. Contact EHS for assistance with lighting issues and for additional information on lighting design.

Each laboratory and laboratory support room should be equipped with emergency lighting. If a laboratory does not have emergency lighting, a flashlight or a battery-powered lantern should be available to provide sufficient lighting to assist personnel in evacuating the laboratory.

4.1.4 Floors

The following recommendations for laboratory flooring are based on OSHA and NFPA regulations:

- Floors in laboratories and laboratory support rooms should be sufficiently reinforced to support the equipment present.
- Floors in laboratories and laboratory support rooms should be made of durable material that requires little maintenance and is resistant to chemical spills.
- Laboratories, laboratory support rooms, and other rooms where laboratory materials are used or stored should not be covered with carpet or rugs.

4.1.5 Laboratory Bench Tops

Laboratory bench tops must be constructed of synthetic materials resistant to the effects of acids, bases, solvents and moderate heat. Bench tops must be capable of supporting the weight of equipment and should be resistant to chipping or damage from routine laboratory operations. Sufficient space must be provided for research activities and equipment placement. Desks and shelves should not be used as a substitute for properly designed bench tops.

4.1.6 Sinks

All laboratories are required to have a fully functional sink with a drain and pressurized water. Sink drains should be made of nonporous material and easily disinfected. The area in and around laboratory sinks should be kept clean and uncluttered so that the sink may be used by personnel to wash their hands before exiting the laboratory.

4.1.7 Lunch and Break Rooms

Lunch rooms, break rooms, and rest rooms must be separate from laboratory areas. Laboratory personnel should remove all PPE and wash their hands before exiting the laboratory and entering other areas.

4.1.8 Telephones

Personnel in laboratories and laboratory support rooms must have access to a telephone that can be used to dial 911 during or after routine work hours. A cellular phone is a sufficient means of emergency communication if the phone has adequate reception. Emergency contact information should be available near the laboratory exit.

4.2 Safety Equipment

Each laboratory should contain or have easy access to the following safety equipment: emergency showers and eye wash stations, first aid supplies, spill supplies, fire suppression equipment, and chemical fume hoods. Additional safety equipment may be required depending on the substances used and procedures performed. In laboratories where biological or radioactive materials are used, the *Biological Safety Manual* and *Radiation Protection Plan*, respectively, list additional safety equipment that may be required. PI/LS are responsible for working closely with EHS so that safety equipment is available to laboratory personnel, routinely inspected, and repaired or replaced as necessary.

4.2.1 Emergency Showers and Eye Wash Stations

In areas where hazardous substances are used, an American National Standards Institute (ANSI) approved emergency shower and eyewash station must be available within a ten-second walk, be clearly labeled, and be easily accessible. All laboratory personnel must know the location of the nearest shower and eye wash stations and must be trained in their use. If an emergency shower or eye wash station is not available, contact EHS.

Emergency showers are designed to provide immediate response to chemical exposures that cover a significant part of the body. Eye wash stations are designed to provide a soft stream of aerated water to rinse the eye. Eye wash stations must be capable of providing water for at least 15 minutes without interruption. Once the flow has begun, hands should be free to hold the eyelids open to better expose eyes to the rinsing action of the water.

Emergency showers and eye wash stations must be installed, maintained, flushed, and tested in accordance with the ANSI Standard for Emergency Eye Wash and Emergency Shower Equipment (Z358.1-2004). Both emergency showers and eye wash stations must be flushed every two weeks to verify that they are operating properly and the effluent is clear. Routine flushing is managed by each department. EHS outlines procedures in the *Emergency Shower and Eyewash Flushing Guide* and distributes supplies necessary for the procedure to each department. Contact the Unit Safety Liaison from your department or EHS for more information. Showers and eye wash stations are tested by EHS every six months to determine if water pressure and flow rate are within acceptable parameters.

4.2.2 Fire Suppression Equipment

A fire extinguisher must be available near the laboratory exit or in the hallway and within 75 feet of the laboratory. It is generally recommended that laboratories be equipped with multipurpose-

type fire extinguishers. The fire extinguisher must be clearly labeled and readily accessible for use and inspection. Once discharged, it must be serviced by a qualified technician or replaced.

Depending on laboratory operations, additional fire suppression equipment, such as a clean agent fire extinguisher or other specialized equipment, may be required. EHS provides fire extinguishers to all George Mason University buildings, inspects extinguishers so that they are in operating condition in the event of an emergency, advises PI/LS regarding appropriate fire suppression equipment for the laboratory, and provides fire safety training to personnel.

Training should be provided to laboratory personnel on the location, use, and limitations of the fire suppression equipment in their laboratory. EHS offers training on the proper use of fire extinguishers. In the event of a fire laboratory personnel are not required to use fire extinguishers but are required to contact emergency services, pull the fire alarms and evacuate the building.

Additionally, the Statewide Fire Prevention Code (SFPC) requires a clearance of 24 inches between the ceiling and any materials in the room to allow proper operation of the fire suppression system.

4.2.3 First Aid and Spill Supplies

All laboratories and laboratory support rooms should be equipped with first aid supplies to assist laboratory personnel in responding to minor injuries and spill supplies relevant to the activities of the laboratory. These supplies should be clearly marked, easily accessible, and located near the laboratory exit. All laboratory personnel must know the location of these supplies. Supplies should be routinely inspected and replaced as necessary. EHS will provide and restock spill and first aid kits upon request.

4.2.4 Chemical Fume Hoods

A chemical fume hood is local ventilation that is designed to limit a user's exposure to hazardous substances. A chemical fume hood functions to capture, retain and ultimately discharge out of the laboratory any noxious or hazardous vapors or fumes. A well-designed chemical fume hood, when properly installed and maintained, offers a substantial degree of protection to the user, provided that it is used correctly and its limitations are understood.

The allowable face velocity for chemical fumes hoods at George Mason University ranges from 80-120 feet per minute (fpm). During use, the sash should be opened to 18 inches or below the user's breathing zone; each chemical fume hood is labeled to indicate this position In the event that the face velocity of a chemical fume hood is below 80 fpm or above 120 fpm or the hood is not operating properly, discontinue use and place a work order with Facilities Management to have the chemical fume hood repaired. All nonfunctioning fume hoods must be reported to EHS.

The air foil located at the front of the fume hood beneath the sash minimizes turbulence and creates smooth air flow for air entering the hood. For this reason all apparatus and equipment should be located at least 6 inches away from the hood face; this distance is also indicated on each chemical fume hood with black and yellow tape.

When a chemical fume hood is not in use, the sash should be closed completely and the surface should be free of all materials and equipment. Chemicals should not be stored in a chemical fume hood but should alternatively be placed in appropriate chemical storage cabinets. Closing of chemical fume hood sashes when not in use reduces energy cost, helps to maintain comfortable conditions in the laboratory, and extends the functional life of the fume hood.

4.2.4.1 Chemical Fume Hood Limitations

A chemical fume hood is not designed to contain particulate matter, explosions, infectious materials, or gas releases from pressurized systems. A chemical fume hood is not a pollution control device. All contaminants that are removed by the ventilating system are released directly into the atmosphere. Apparatus used in hoods should be fitted with condensers, traps, or scrubbers to contain and collect waste solvents or toxic vapors or dusts. A chemical fume hood should not be used for waste disposal by way of evaporation. It is a violation of environmental regulations to intentionally evaporate hazardous chemicals in the chemical fume hood.

4.2.4.2 Chemical Fume Hood Inspections

Chemical fume hood inspections are conducted:

- At least annually (more frequently if required by funding agencies);
- Following installation of a new chemical fume hood or renovation of a room where a chemical fume hood is located;
- When maintenance is performed on a chemical fume hood;
- Per request by the PI/LS if chemical fume hood performance is unsatisfactory; and
- As required due to specific laboratory operations conducted in a laboratory.

Each chemical fume hood should be labeled with an inspection sticker that displays the date that the hood was inspected, the measured face velocity, and the name of the inspector who conducted the test. Chemical fume hoods that fail inspection cannot be used until they are repaired and retested.

4.2.4.3 Using Chemical Fume Hoods

Good laboratory practices must be employed while performing work in a chemical fume hood to facilitate adequate protection. A list of recommended practices follows:

- Use a chemical fume hood or other local ventilation device when working with volatile substances with a threshold limit value (TLV) less than 50 parts per million (ppm).
- Design experiments in consideration of chemical fume hood space and air flow.
- Before beginning work, verify that the type of chemical fume hood to be used and the face velocity are appropriate for the chemicals involved and the procedure to be performed.
- Do not use perchloric acid in a conventional chemical fume hood. Perchloric acid vapors accumulate in ductwork and form perchlorate crystals that have the potential to explode, causing serious injury to personnel and damage to property. If laboratory activities require use of perchloric acid, contact EHS.

- Check areas around the chemical fume hood for sources of cross drafts that may cause turbulence and result in leaks from the hood into the laboratory. Other personnel working in the laboratory should avoid walking behind individuals conducting work at the fume hood to reduce negative turbulence. Doors should remain closed reduce to maintain negative pressure in the laboratory relative to the hallway.
- Ensure that the inspection sticker is current (within one year).
- Verify that the reading from the continuous air flow monitoring device is no less than 80 fpm, no greater than 120 fpm, and within 15% of the face velocity value listed on the inspection sticker. If the reading differs significantly from that on the sticker, the chemical fume hood may not be operating properly. (Contact EHS so that the hood can be reevaluated.)
- Visually inspect the baffles (openings at the top and rear of the hood) to be sure that the slots are open, unobstructed, and set to the proper configuration based on the chemicals used.
- Conduct all experiments at least 6 inches from the front of the chemical fume hood.
- Provide secondary containment for containers that could break or spill.
- If large equipment must be placed in the chemical fume hood, use blocks to raise it approximately 2 inches above the surface so that air may pass beneath it.
- Ensure that all electrical devices are connected outside the chemical fume hood to avoid an electrical arc that can ignite a flammable or reactive chemical.
- Clean all chemical residues from the chemical fume hood chamber after each use.
- Keep the sash completely lowered when the chemical fume hood is not in use or when an experiment in the hood is left unattended.
- Chemicals and equipment should not be stored in the chemical fume hood.

4.2.5 Other Laboratory Exhaust Ventilation

Many laboratories use equipment that can generate airborne contaminants but cannot be used within a chemical fume hood. Examples include gas chromatographs, ovens, and vacuum pumps. Other types of local exhaust ventilation may be required to control contaminants generated by these operations. Such ventilation must have a separate exhaust duct and must not be installed without approval from EHS. Consult EHS before installing, modifying, or purchasing laboratory ventilation equipment to verify that it conforms to all relevant safety, building, and fire code regulations. For more information on laboratory ventilation and local ventilation, reference the *Laboratory Ventilation Management Plan.*

Biosafety cabinets should be used for work involving infectious material. Chemical fume hoods are not designed to protect against aerosolized biohazardous material. More information about biosafety cabinets is provided in the *Biological Safety Manual.*

4.2.6 Additional Safety Equipment

Laboratories where biohazardous material or sources of ionizing radiation are used or stored may require additional safety equipment. Please refer to the *Biological Safety Manual* and *Radiation Protection Plan* for more information.

5.0 Administrative Controls

Administrative controls are precautionary measures implemented to reduce the risk of accidents in the laboratory through training, signage and labeling, record keeping, and medical surveillance. Administrative controls should be established prior to beginning a laboratory project or protocol.

5.1 Training

George Mason University laboratory personnel, students, support services staff, and visitors entering laboratories or laboratory support rooms are required to receive safety training commensurate with their level of participation in laboratory activities and the duties they are to perform. EHS provides training in general laboratory safety awareness, chemical safety, biosafety, radiation safety, and laser safety in accordance with relevant guidance and regulatory requirements. Personnel can view a complete list of training offered by EHS and register for training through the EHS website (ehs.gmu.edu).

5.1.1 Laboratory Safety Awareness

Laboratory Safety Awareness training offers nonlaboratory personnel a fundamental overview of laboratory hazards, hazard identification, and emergency response. Specific *Laboratory Safety Awareness* training is offered to Facilities Management and University Police. Each training course focuses on the specific duties and safety concerns of the trainees.

5.1.2 Laboratory Safety Orientation

All personnel working in George Mason University laboratories are required to participate in *Laboratory Safety Orientation*, unless they work in a BSL-2 laboratory, in which case *Biological Safety for BSL-2 Laboratories* training is required in lieu of *Laboratory Safety Orientation* training.

Laboratory Safety Orientation will serve as the foundation for all participants who are new to George Mason scientific instructional or research laboratories. This course will instruct participants on Mason-specific laboratory safety policies and procedures, chemical safety and hygiene, risk assessment and management, waste management guidelines, and emergency response information. This course will also introduce participants to best practices for chemical and noninfectious biological material work within the laboratory, as well as services available to laboratory personnel through EHS.

This training must be renewed annually. Once you have taken this training course, you may substitute *Laboratory Safety Refresher* training to meet the annual requirement.

5.1.3 Biological Safety for BSL-2 Laboratories

All individuals working in or frequenting laboratories where infectious materials are used or stored must receive *Biological Safety for BSL-2 Laboratories* training before beginning work with infectious materials. This training reviews the principles of biosafety including risk

assessment and management strategies, risk groups and biosafety levels safe laboratory practices, methods of disinfection and decontamination, waste management, and spill and exposure response. Additionally, this course will instruct participants on Mason-specific laboratory safety policies and procedures, chemical safety and hygiene, risk assessment and management, waste management guidelines, and emergency response information *Biological Safety for BSL-2 Laboratories* must be renewed annually and can be renewed by attending *BSL-2 Biosafety Refresher* within 12 months.

5.1.4 Bloodborne Pathogens

In accordance with the OSHA Bloodborne Pathogen Standard, training on risks associated with bloodborne pathogens, safe laboratory practices, medical waste management, and emergency procedures is provided annually to all individuals at occupational risk for exposure to bloodborne pathogens. Individuals working in or frequenting laboratories or clinical settings where bloodborne pathogens or other potentially infectious materials are present must receive bloodborne pathogens training before beginning work. Training must be renewed annually.

5.1.5 Laser Safety

The Laser Safety Officer provides laser safety training in accordance with ANSI Standard z136.1. Information about laser safety training is available in the *Laser Safety Manual*.

5.1.6 Radiation Safety and X-ray Safety

EHS provides radiation safety training to all individuals working in or routinely entering laboratories where radioactive material or instruments that produce ionizing radiation are used. Training is also required for individuals who receive radioactive materials packages. X-ray safety training is provided to personnel who use x-ray producing devices. Additional training opportunities are discussed in the *Radiation Protection Plan*.

5.1.7 Magnetic Resonance Imaging (MRI) Safety

MRI safety training is provided to personnel who have access to or conduct work within the MRI suite. Additional information is provided in the *MRI Policies and Procedures Manual* and on the EHS website.

5.1.8 Animal and Vivarium Safety

This training reviews the risks associated with handling animals in the research laboratory environment, vivarium facility safety procedures, zoonotic diseases, PPE, animal waste handling and disposal, and laboratory animal allergens. This training must be renewed annually. Once you have taken this training course, you may substitute *Animal & Vivarium Safety Refresher* training to meet the annual requirement.

5.1.9 Specific Personal Protective Equipment (PPE)

OSHA requires that all individuals who are issued respiratory protection or hearing protection devices be enrolled in the George Mason University *Respiratory Protection Program* and

Hearing Conservation Program, respectively. These programs are administered by EHS, and annual training is required as part of these programs. Personnel whose work requires the use of respiratory protection [e.g., half face, full face, Powered Air Purifying Respirator (PAPR), particulate mask (including N95 or N99 filtering face piece)] or hearing protection devices (e.g., ear muffs, ear plugs) must contact EHS prior to beginning work.

5.1.10 Laboratory Specific

In addition to training provided by EHS, laboratory personnel must receive training specific to the laboratory in which they work. This training is provided by the PI/LS, should be based on the *Supplemental Laboratory Safety Plan*, and must include such topics as risks associated with the hazardous substances in the laboratory, physical hazards present in the laboratory, proper use of instruments and safety equipment, and laboratory procedures and protocols. To verify receipt of laboratory-specific training, laboratory personnel must sign the *Laboratory Training Signature Page* kept in the *Safety Records and Resources* binder. A blank copy of the *Laboratory Training Signature Page* is available on the EHS website.

5.1.11 Instructional Laboratories

Laboratory safety training for students enrolled in instructional laboratories is provided by the course instructor. Training must include a discussion of the risks associated with the substances used and procedures to be performed, proper techniques for handling and disposing of hazardous substances, safety precautions to be used to prevent exposure or release into the environment, PPE usage, and emergency and spill procedures. EHS is available to assist course instructors in developing this training and will provide additional laboratory safety training in instructional courses upon request.

5.2 Prior Approval

In order to comply with government regulations regarding hazards in research and instructional laboratories and to provide a safe and healthful work place, George Mason University requires that research and instructional projects undergo review prior to the project start. Prior approval must be obtained for the use of hazardous substances, animal subjects, and human subjects.

5.2.1 Review of Projects Involving Biological Materials or Sources of Ionizing Radiation

To initiate review of projects involving biological materials or sources of ionizing radiation, PI/LS must submit to EHS a *Project Review Form*. The *Project Review Form* is a tool to facilitate review of laboratory projects to maintain compliance with federal, state, and local regulations. All PI/LS using biological materials or sources of ionizing radiation are required to complete a *Project Review Form* for each research project or instructional course. The *Project Review Form* and instructions for completing the form are available on the EHS website.

Submitted forms will be reviewed by the IBC and/or the RSC and must be approved by the committees prior to work beginning on the project. The appropriate committees will evaluate the proposed project to evaluate the safety precautions to be employed and compliance with relevant regulatory requirements. Depending on the nature of the project and materials used, the committees may request revisions to the project design before approving the project. (More

information is available about the IBC and RSC in the *Biological Safety Manual* and *Radiation Protection Plan*, respectively.)

In addition to IBC approval, the use of select agents and toxins must be registered with the United States Department of Health and Human Services and/or the United States Department of Agriculture. EHS serves as point of contact for these federal entities and administers the university's Select Agent Program. Therefore, PI/LS considering work with select agents and toxins must first contact EHS to initiate the approval process. Contact EHS for more information regarding work with select agents and toxins.

Approval for all projects expires 36 months after the IBC or RSC date of approval. EHS will contact PI/LS several months before the expiration of their Project Review Form to facilitate the renewal process. *Project Review Forms* should be updated as frequently as necessary to reflect changes in experimental protocols, the types or amount of material used, laboratory personnel, or location. Significant procedural changes such as modifications in laboratory procedures, project design, the types or amounts of materials used, or laboratory location may require safety committee review before the changes can be implemented. More information about project review and the *Project Review Form* is available on the EHS website.

5.2.2 Review of Projects Involving Animal or Human Subjects

ORIA, along with IACUC and the IRB, oversees review of projects involving animal or human subjects. See the ORIA website for more information.

5.2.3 Review of Projects Involving Particularly Hazardous Substances

PI/LS must review and approve new laboratory projects, tests, or procedures before they are initiated by laboratory personnel. Special consideration should be given to projects that involve Particularly Hazardous Substances (see lists of select carcinogens, reproductive toxins, and acutely toxic chemicals on the EHS website). Review of projects involving these substances should be done in cooperation with the Chemical Hygiene Officer and should examine the manner in which the chemicals are to be used, stored, and discarded. Appropriate safety measures should also be considered. Standard operating procedures (SOP) for projects involving Particularly Hazardous Substances should be kept with the *Supplemental Laboratory Safety Plan*. Projects should be reevaluated for safety if any of the following conditions arise:

- A new laboratory test or procedure is to be conducted.
- Potential exists for chemical exposure above the permissible exposure limit (PEL) or TLV, whichever is lower.
- A significant change occurs in project procedures, project design, or the types of chemicals used.
- A significant change (approximately 10%) is to be made in the amount of hazardous chemicals used.
- An experiment or project will be run unattended on a frequent basis.
- The project will be managed by one person and they are the sole occupant of the laboratory.
- A significant spill or accident occurs.

- Someone is injured or exposed while working.
- An emergency occurs while conducting routine laboratory activities.

EHS is available to assist PI/LS in reviewing procedures and in developing appropriate SOP.

5.2.4 Restrictions for Minors in the Laboratory

There may be occurrences where experiential learning and the laboratory environment will intersect. PI/LS may be asked to facilitate this type of experience in his or her laboratory with an individual under the age of 18 who is not enrolled in courses at George Mason University (herein referred to as a *minor*). Due to potential risks associated with the laboratory environment, access to all university laboratories is restricted for minors.

EHS has developed the *Minors in the Laboratory Guide* (available on the EHS website) to assist PI/LS with the process of reviewing, approving, and assessing risk for minors who would like to participate in laboratory activities. This document also provides guidance for PI/LS on activities that involve minors such as: laboratory tours, required safety training, documentation of risk assumption by the minor's parent or legal guardian, as well as medical clearance requirements and forms.

5.2.4.1 Children Under the Age of Twelve

Children under the age of 12 are permitted in university research laboratories only when they are participants (subjects of study) in an approved research study; children under the age of 12 are not permitted in university research laboratories for any other reason. Laboratories must never be utilized as a substitute for child care.

5.2.4.2 Visitors Ages Twelve to Seventeen

Persons between the ages of 12 and 17 may visit research laboratories as part of officially-supervised educational activities that have been approved by the PI/LS.

- These visiting minors must be under the direct supervision of a university employee who is trained and knowledgeable of applicable hazards.
- No minor shall be present during any activity with the potential for exposure to hazardous materials.
- Prior to allowing minors to tour or observe in a laboratory, the supervising employee must conduct a basic safety orientation, including both general safety information and any hazards particular to the lab in question. The PI/LS should maintain documentation of dates of training and a list of attendees.

5.2.4.3 Laboratory Participants Ages Sixteen and Seventeen

George Mason University is committed to providing educational and research opportunities, when feasible, to minors ages 16 and 17. PI/LS are permitted to have minors ages 16 and 17 participate in and perform educational activities and routine education-related duties in a research laboratory.

- A risk assessment must be on file with EHS for all projects involving minors.
- Minors must be supervised at all times in the laboratory.
- Minors are not permitted to visit or work in laboratories operating at BSL-3 or ABSL-3 or other high-hazard locations such as a machine shop.
- Minors may not perform work involving:
    - Agents on the federal select agent list;
    - Highly hazardous substances including pyrophorics and explosives;
    - Large quantities of flammable substances;
    - Controlled Substances; and
    - Substances of high acute toxicity having a rat lethal dose (LD) 50 less than or equal to 50 mg/Kg (e.g., sodium azide, nicotine, etc.).

5.2.4.4 PI/LS Requirements for Work Involving Minors

The following requirements are in place for PI/LS who will be supervising minors. If the responsibility of supervising the minor will be delegated to a staff member, the staff member must meet these requirements:

- Ability to provide supervision at all times to the minor during laboratory activities.
- Successful completion of a background check through the university in accordance with University Policy Number 2221, Background Investigations.
- Current on all safety training.
- Knowledge and understanding of laboratory hazards and proper safety controls.

5.2.4.5 Registration Process for Work Involving Minors

All work involving minors must be approved by EHS prior to project start. The PI/LS is responsible for submitting all required paperwork to EHS for review. The forms and documents listed below are available on the EHS website.

- Upon agreeing to mentor a minor in the laboratory, the PI/LS completes the *Release for Laboratory Volunteers and Minors* form and submits to labsafe@gmu.edu.
- A *Teacher Recommendation Form* must be completed and submitted electronically to PI/LS and EHS.
- EHS will review the submission and approve or deny the project.
- PI/LS will forward approval to parent/guardian along with the *Release for Laboratory Volunteers and Minors*. A signed *Release for Laboratory Volunteers and Minors* must be on file in the laboratory and with EHS before beginning work.
- Minors must attend safety training relevant to the work to be performed.

5.3 Laboratory Security and Access

Laboratories contain hazardous substances that can pose a serious danger to public health if handled by untrained personnel or removed from the laboratory. In addition, laboratories contain expensive instruments and equipment that must be protected from unauthorized use, vandalism,

and theft. Therefore, it is imperative that PI/LS implement appropriate security precautions to prevent unauthorized individuals from gaining access to laboratory materials and equipment. To secure the laboratory, PI/LS should:

- Identify potential security risks in the laboratory (e.g., laboratory doors left open, doors left unlocked when the laboratory is unattended, or unsecured hazardous substance storage areas).
- Develop and implement laboratory security procedures to prevent unauthorized entry to the laboratory and access to hazardous substances.
- Develop and implement laboratory access restrictions to protect the health and safety of individuals entering the laboratory. Laboratory hazards and access restrictions for all laboratories should be clearly indicated at the entrance to the laboratory.
- Train laboratory personnel to implement security procedures.

The following security procedures must be followed in all laboratories:

- Keep doors closed at all times and locked when no authorized personnel are present.
- Do not leave hazardous substances unattended or unsecured at any time.
- Restrict access to freezers, refrigerators, storage cabinets, and other equipment where hazardous substances are stored.
- Limit laboratory access to approved laboratory personnel who are properly trained with regard to the hazards present in the laboratory and the type of work they will perform.
- Restrict off-hours access to individuals authorized by the PI/LS.
- Escort visitors to and from the laboratory**.**
- Challenge or question unfamiliar or suspicious individuals that gain access to restricted areas or to the laboratory. Report these incidents to University Police.
- Report any missing inventory to University Police.
- Report all acts of vandalism, theft, or suspicious activities to University Police.

5.3.1 Restricted Access for Visitors

Visitors (including minors) should not be allowed to enter laboratories unattended and should be escorted to and from the laboratory by George Mason University personnel. Visiting minors must be under the direct supervision of a university employee who is trained and knowledgeable of applicable hazards. Prior to allowing visiting to tour or observe in a laboratory, the supervising employee must conduct a basic safety orientation, including both general safety information and any hazards particular to the lab in question. A *Release for Laboratory Volunteers and Minors* is required for visitors to enter a laboratory. The PI/LS should maintain documentation of dates of training, a list of attendees, and *Release for Laboratory Volunteers and Minors* forms. The latter should be submitted to EHS via labsafe@gmu.edu.

5.3.2 Restricted Access for Support Services Staff

All support services staff (e.g., housekeeping, facilities management, police, etc.) must receive appropriate training prior to entering laboratories or laboratory support rooms. Once trained,

support services staff may enter laboratories and laboratory support rooms with the exception of specific rooms designated as restricted areas.

Restricted areas include laboratories that house animals, hazardous waste storage rooms, BSL-3 laboratories, radioactive materials, and other areas with unique hazards. These laboratories are labeled with a restricted access symbol (Figure 1). Support services staff are not permitted to enter restricted areas unless requested by PI/LS or EHS. In this situation, the person requesting the service must submit a work order and arrange for access. EHS maintains a current list of restricted areas. For BSL-3 laboratories, staff must be escorted by EHS personnel.

Figure 1. Restricted Access Symbol.

For nonrestricted laboratories and laboratory support rooms, support services staff must notify the unit of nonroutine services (e.g., mopping and waxing floors, light bulb replacement, and equipment inventory) at least 10 university working days in advance of when the work is to occur. PI/LS may request that services be scheduled at a time that does not interfere with ongoing laboratory operations or critical experiments.

Support services staff has been instructed that they need not perform any services which make them uncomfortable or of which they are unsure. Specifically, housekeeping staff has been instructed that they should not clean pools of liquid on laboratory floors.

5.4 Signs and Labels

Signs and labels are used to clearly identify specific laboratory hazards, safety equipment, emergency supplies, designated areas within the laboratory and other important information. The following signage requirements apply to all laboratories and laboratory support rooms at George Mason University.

5.4.1 Laboratory Entryway Signs

The entrance to all laboratories and laboratory support rooms must be posted with signs that indicate the hazards present in the laboratory, appropriate PPE to be worn, access restrictions, and contact information to be used in the event of an emergency. EHS provides entryway signs for all laboratories and laboratory support rooms (Figure 2). Contact EHS to receive a sign or to make corrections to an already existing sign.

Figure 2. Laboratory Entryway Sign

Laboratories containing equipment that may pose a potential health risk (such as MRI scanners) must have warning signs posted at the entrance to the laboratory and at a safe distance from the entrance. These warning signs must indicate the type of hazard present and identify any particular risks associated with this hazard.

5.4.2 Emergency Contact Information

Each laboratory must post emergency contact information near the laboratory exit. The following information should be provided: office phone number of the PI/LS responsible for the laboratory, after hours contact information, contact number for EHS, and contact number for University Police.

5.4.3 Labeling Equipment and Designated Areas

The following items must be identified with labels or signage:

- Safety equipment;
    - Emergency shower;
    - Eye wash station;
    - First aid supplies;
    - Fire extinguishers;
    - Fire blankets; and
    - Spill supplies.
- Designated areas for work with Particularly Hazardous Substances;
- Satellite accumulation area;

- Chemical storage areas;
- Unique hazards;
- Electromagnetic equipment;
- Thermal hazards;
- Electrical hazards; and
- Mechanical hazards.

5.4.4 Laboratory Equipment

Broken equipment that is not operational must be taken out of service and labeled to prevent further use by laboratory personnel. Notify EHS immediately of broken or malfunctioning safety equipment (e.g., chemical fume hoods, biosafety cabinets, emergency shower, etc.).

5.4.5 Additional Signage

All laboratory equipment (e.g., refrigerators, freezers, centrifuges, and incubators) and waste disposal containers in which biohazardous material or radioactive materials are used or stored must be labeled to indicate the type of hazard present. For biohazardous materials, the label must contain the universal symbol for biohazard (Figure 3) and the word "Biohazard". For radioactive materials and instruments that produce radiation, the label must contain the universal symbol for radiation, the words "Caution, Radioactive Materials" or "Caution, Radiation", and identify the specific radioisotope (Figure 4). Labels should be affixed to the container or as close as possible to the container using string, wire, adhesive, or any other method that prevents their loss or unintentional removal.

Figure 3. Universal Biohazard Symbol

Figure 4. Universal Radiation Symbol

Finally, before any equipment used with hazardous chemical, biohazardous materials, or radioactive materials can be sent for repair, surplus, or disposal, it must be decontaminated and labeled with a *Decontamination Certificate* (available on the EHS website).

5.5 Required Safety Records

PI/LS are required to maintain records regarding laboratory safety and compliance. Records should be kept in a central location where they are available to laboratory personnel and inspectors. To facilitate recordkeeping, EHS provides wall bins in each laboratory where safety manuals, the *SDS Library*, and safety and compliance records may be kept. A *Safety Records and Resources* binder is provided by EHS to store laboratory records such as the *Supplemental Laboratory Safety Plan*, inventory records, and training documents. A list of required safety records is provided below.

5.5.1 Laboratory Safety Manual

To comply with 29 CFR 1910.1450, a copy of the *Laboratory Safety Manual* (which serves as George Mason University's Chemical Hygiene Plan) must be available in each laboratory and laboratory personnel must be familiar with the manual.

5.5.2 Supplemental Laboratory Safety Plan

A current copy of the *Supplemental Laboratory Safety Plan* must be kept in the Safety Records and Resources binder in each laboratory. The plan should be updated as frequently as necessary to reflect projects ongoing in the laboratory and changes in personnel. A template that can be used to develop the *Supplemental Laboratory Safety Plan* is attached and is on the EHS website.

5.5.3 Chemical Inventory

Each research and instructional laboratory is required to maintain a chemical inventory that includes all of the chemicals stored in the laboratory. Chemical inventories are maintained through the EHS Assistant database. PI/LS, or their designee, are responsible for updating the database at the beginning of each semester and maintaining current chemical inventory records. To access the EHS Assistant, click on the Member Login link on the EHS website (ehs.gmu.edu). Use your MESA login and password. An updated Chemical Inventory Report should be kept in the *Safety Records and Resources* binder. Procedures for maintaining chemical inventories are outlined in the *Chemical Inventory Requirements Guide*.

5.5.4 Safety Data Sheet (SDS) Library

SDS contain product information regarding hazards associated with the substances the product contains. Chemical manufacturers must provide SDS for each chemical they produce. Many manufacturers provide SDS online and may not include paper copies with each chemical delivery. Maintaining an *SDS Library* in each laboratory provides laboratory personnel the information necessary to safely manage chemicals, identify potential hazards, and design laboratory projects with consideration to chemical hazards. The *SDS Library* also serves to inform laboratory and emergency personnel of the correct actions to take in the event of an emergency and how to effectively respond to a chemical spill. Each SDS contains the following information:

- Identification;
- Hazard(s) identification;

- Composition/information on ingredients;
- First-aid measures;
- Fire-fighting measures;
- Accidental release measures;
- Handling and storage;
- Exposure controls/personal protection;
- Physical and chemical properties;
- Stability and reactivity;
- Toxicological information;
- Ecological information;
- Disposal considerations;
- Transport information;
- Regulatory information; and
- Other information.

It is the responsibility of the PI/LS to provide and maintain the *SDS Library* in their laboratory and update it regularly to reflect the inventory of the laboratory.

- EHS provides a binder for the *SDS Library*.
- SDS should be filed alphabetically and stored in a conspicuous location, such as the wall bins provided by EHS.

PI/LS may elect to maintain an electronic *SDS Library* or use a computer database for larger inventories of 100 chemicals or more to reduce storage, facilitate more expedient searches, and provide a more sustainable alternative to paper, provided that:

- The electronic *SDS Library* is maintained on one or more rechargeable devices; tablets, laptops, etc., dedicated for SDS inventory management in the laboratory where the chemicals are stored and used.
- The device/s must;
    - Remain charged for use in the event of a power outage,
    - Be accessible to all personnel in the laboratory at all times, and
    - Be conspicuously labeled "*SDS Library*".
- All laboratory personnel are trained in how to look up and retrieve SDS.

If the preceding provisions cannot be met, a printed *SDS Library* must be available so that SDS are available in the event of a power outage.

5.5.5 Training Records

PI/LS are responsible for providing laboratory-specific training and verifying that laboratory personnel complete the *Laboratory Training Signature Page* which must be kept in the *Safety Records and Resources* binder. EHS maintains records of training provided by EHS in EHS Assistant.

5.5.6 Additional Records for Biological Laboratories

Additional records required for laboratories using biological materials include:

- *Biological Safety Manual*;
- SDS for biohazardous materials used or stored in the laboratory (when available); and
- Copies of approved *Project Review Forms*.

See the *Biological Safety Manual* for more information.

5.5.7 Additional Records for Radiation Laboratories

Additional records required for laboratories using sources of ionizing radiation include:

- *Radiation Protection Plan;*
- *Radiation Inventory Use and Disposal Log* for all open sources of radioactive material; and
- Monthly and post-experiment wipe test and monitoring records (if applicable).

See the *Radiation Protection Plan* for more information.

5.6 Laboratory Inspections

George Mason University is periodically inspected by federal, state, and local agencies. These regulatory agencies may visit George Mason University at any time, with or without prior notification, to assess safety and compliance at the university. During these visits, inspectors may ask to examine laboratories and laboratory support rooms, question laboratory personnel, and examine laboratory records.

EHS routinely inspects each laboratory and laboratory support room. Inspections are performed in accordance with government regulations and funding agency stipulations, and are used to address safety issues identified in the laboratory. The IACUC conducts facility inspections twice a year to evaluate the effectiveness of control measures in place to reduce the risk of injury and illness of personnel working with or near laboratory or research animals. EHS inspections also serve to prepare laboratories for inspections from outside agencies.

EHS inspections examine laboratory entrance and egress, documentation, housekeeping and facility design, emergency equipment/supplies, personal protective equipment, fume hoods, chemical safety, biological safety, radiation safety, laboratory waste, as well as electrical and mechanical safety. A list of the laboratory safety inspection categories is available on the EHS website.

PI/LS are encouraged to participate in EHS inspections. Following an inspection, PI/LS will receive a letter from EHS that identifies safety issues and corresponding corrective actions. Egregious violations of safety policies must be dealt with immediately. For minor issues, PI/LS will be given an appropriate amount of time to make required changes. After this time period, EHS will follow-up to determine if appropriate corrective actions have been taken.

EHS has the authority to close laboratories or discontinue certain activities when there is an immediate or imminent threat to human health, property, or the environment. Additionally, laboratories that persistently fail to comply with safety regulations and George Mason University safety standards may be closed until necessary modifications, improvements, or corrective actions are completed. EHS will assist all laboratories in meeting regulatory compliance and safety standards.

PI/LS may request that EHS perform an informal inspection of their laboratory to identify safety concerns and to assist them in meeting government regulations. PI/LS interested in scheduling an inspection should contact EHS.

5.7 Exposure Monitoring

Exposure monitoring is be conducted when there is reason to believe that exposure levels for a chemical may exceed the regulated limits. Exposure monitoring may be required when modifications to laboratory ventilation equipment occurs or when Particularly Hazardous Substances are used regularly.

After an exposure, EHS and PI/LS will review the operations of the laboratory and implement corrective actions [changes in administrative controls, engineering controls (e.g., modifications to procedures or chemical substitutions) or PPE] designed to reduce or eliminate exposure to hazardous substances.

5.8 Medical Surveillance

George Mason University is required by OSHA in 29 CFR and Virginia Administrative Code (16 VAC 25-90) to ensure that employees exposed to health hazards at work are included in a medical surveillance program. Medical surveillance is a series of medical services provided by PLHCP for the primary prevention of occupational injuries and illnesses, including a review of occupational and medical history, physical exams, diagnostic and performance testing, and vaccinations. George Mason University's *Medical Surveillance Plan* complies with applicable regulations and guidelines and establishes minimum medical surveillance requirements to prevent occupational injuries and illnesses for George Mason University employees whose job duties place them at risk of exposure to occupational hazards. The *Medical Surveillance Plan* is available on the EHS website.

Among the services offered through EHS are medical screening and health assessments, immunizations, consultation regarding health risks, and exposure incident monitoring. These services are provided at no cost to employees. In addition, an employee has the right to seek medical care pursuant to 29 CFR 1910.1450 (g), should any of the following occur:

- Personnel experiences signs or symptoms associated with chemical exposure.
- A spill, leak, explosion, or other occurrence resulting in the likelihood of an exposure.
- Exposure monitoring reveals an exposure level above the PEL.
- Routine (e.g., three times a week) use of chemicals with high chronic toxicity.

Under these conditions, medical care must be performed without the loss of pay at a reasonable time and place. Laboratory personnel who are not George Mason University employees (e.g., unpaid visiting faculty, volunteers, graduate students, and undergraduate students) are not covered under the *Medical Surveillance Plan*. These individuals should discuss the nature of their laboratory work with their healthcare provider and should have personal health coverage.

EHS maintains medical surveillance records (employee name, employee G number, PLHCP written opinion) for a period of 30 years after termination of employment.

5.9 Animal Laboratories

The National Research Council and NIH have developed industry standards and guidelines that require specific actions to be completed prior to the handling of laboratory and research animals. The *Biological Safety Manual* provides guidance on protecting personnel from hazards specific to the care and use of laboratory and research animals, and outlines occupational hazards, risk assessment, hazard assessments, injury and illness reporting, and training requirements for personnel.

6.0 Personal Protective Equipment (PPE)

PPE must be provided to and worn by all laboratory personnel, students, and visitors, when entering a laboratory including spaces where research animals are present. The extent and type of PPE selected for a particular activity depends on the risks associated with laboratory operations to be performed. At a minimum, a lab coat, gloves, clothing that covers the legs, and closed–toe shoes must be worn when working with laboratory materials. Shoe covers, forearm protection, eye protection, or a respirator may be required depending on the type of work being conducted. SDS provide specific PPE recommendations for handling chemicals. The *Biological Safety Manual* and *Radiation Protection Plan* provide additional PPE recommendations for handling biological materials and animals and sources of ionizing radiation, respectively.

PPE should be durable, designed to provide adequate protection, and capable of preventing exposure to hazardous substances. PPE must be removed before leaving the laboratory unless it is being used to safely transport substances between rooms and buildings. PPE should be worn to transport materials between laboratories in the same building. PPE worn for this purpose should be clean to prevent contamination of communal areas. Only one hand should be gloved so that one hand is free to touch communal surfaces (e.g., door handles, elevator buttons).

While PPE is an important component of a comprehensive laboratory safety program, it is most effective when used in conjunction with and should not be a substitute for engineering controls, administrative controls, good laboratory practices, and safety equipment. OSHA requires the use of PPE to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective in reducing these exposures to acceptable levels.

6.1 Personal Clothing

Personal attire must be considered when working in a laboratory, as clothing, accessories, and hair may become entangled in equipment, accidentally spill substances, or pass through flames unintentionally. Proper personal attire includes clothing that provides adequate coverage for the legs and close-toed footwear that provides adequate support and has suitable traction for laboratory activities. Hair should be confined or tied back. The following should not be worn in the laboratory: loose sleeves, dangling jewelry, clothing that leaves the legs exposed, or shoes with heels greater than one inch.

6.2 Eye Protection

Eye protection must be worn when working with substances or equipment that present a hazard to the eye. Eye protection must meet design requirements set forth by ANSI (Z87.1-1998) and must be appropriate for the activity being performed.

Safety glasses should fit securely and be free of smudges or scratches that may obstruct vision. Safety glasses are designed for impact hazards and may be equipped with side shields to provide more complete protection than those without. Safety goggles provide an increased level of protection and should be worn when splashes may occur or glassware may explode/implode under pressure.

6.3 Face Shields

Face shields are designed to be used in combination with safety goggles to provide additional protection to the face and eyes against splashes and particulate matter. Face shields do not provide adequate protection against large projectiles or liquids, unless they are used in combination with safety goggles. Polycarbonate face shields that offer protection against ultraviolet (UV) radiation should be worn when using instruments that produce UV light and do not have UV filters.

6.4 Gloves

Gloves should always be worn when working with chemicals even if the chemical containers are tightly closed or the experiment being conducted is within a closed system. Gloves should be comfortable, of sufficient length to prevent exposure of the hand and wrist, and should be appropriate for the type of work to be performed. Gloves should be inspected for visible tears before use, changed when they become soiled or compromised, and discarded appropriately after use.

Gloves come in a variety of materials that provide different levels of protection. Laboratory personnel should use gloves that provide the highest level of protection against the substances to be used. Some individuals develop allergies to the materials used to manufacture gloves. If this occurs, select a comparable glove made of an alternate material.

6.5 Lab Coats and Aprons

Lab coats must be provided to and worn by all laboratory personnel, students (including those in instructional laboratories), and visitors when entering a laboratory. Lab coats must provide adequate protection from the risk of contamination and must be laundered on a routine basis. Only single use disposable lab coats or lab coats that are routinely laundered by an approved vendor may be used. Lab coats may not be laundered by laboratory personnel. Each department is responsible for maintaining a contract with an outside vendor that provides lab coats and laundering services. Additional considerations when selecting lab coat are listed below.

- Lab coats should be properly sized, extend from the neck to the knees, and cover the full length of the arm.
- Lab coats should have fasteners (such as snaps) that allow for easy removal in case of contamination.
- Lab coats should be made with flame-retardant material if working with open flames, large quantities of flammable materials, or pyrophoric chemicals.
- Pockets should be on the outside of the coat (not the inside) to minimize potential contamination of street clothes or skin.
- Personnel operating at BSL-2 should have cuffed sleeves to provide continuous coverage from the wrist to the forearm and prevent the coat from riding up during work with infectious material.

Lab aprons are designed to be worn in combination with a lab coat to provide extra protection when pouring corrosive chemicals, using an acid bath, or manipulating chemicals in a manner

that increases the likelihood for splashes or spills. Lab aprons should fit comfortably and extend from just below the neck to just above the tops of the feet.

6.6 Respiratory Protection

Respiratory protection requirements vary depending on the type of respiratory hazard present. In general, respiratory protection should fit snugly and form a seal so that air may not leak through the sides of the respirator. George Mason University's *Respiratory Protection Plan* is available on the EHS website and provides additional information and guidance on the use, care, and maintenance of respirators.

If your work requires you to wear respiratory protection [e.g., half face, full face, PAPR, particulate mask (including N95 or N99)], you must contact EHS prior to beginning work.

6.7 Hearing Protection

George Mason University's Hearing Conservation Program as outlined in the *Hearing Conservation Plan* covers any employee exposed to noise levels in excess 85 A-weighting decibels (dBA) over an eight-hour period. The program is available on the EHS website and provides additional information on the use and care of hearing protection devices. Hearing protection, provided by ear plugs or ear muffs, should be worn by personnel exposed to 85 dBA over an eight-hour period.

Employees must be enrolled in the Hearing Conservation Program if they are assigned to a work area (or work in a similar exposure group) where occupational exposure to noise exceeds the action level of 85 dBA. In some laboratories, the combination of noises generated by continuously running equipment (e.g., refrigerators, freezers, and incubators) and intermittent use of equipment such as centrifuges, motors, sonicators, and homogenizers may reach levels that exceed 85 dBA. As a general rule, if an employee must raise his/her voice to speak with someone less than 1 meter away, then noise levels probably exceed 85 dBA. If you believe noise levels may exceed the action level, contact EHS.

7.0 Chemical Hazards

The hazardous nature of a chemical is determined by the potential for the chemical to cause adverse health effects (toxicity) and the physical hazards inherent to the properties of the chemical (e.g., flammability, reactivity).

7.1 Toxicity and Toxicology

The toxicity of a chemical is the ability of that chemical to cause a reproducible dose-dependent effect on a biological system. The conditions of exposure and the susceptibility of the exposed individual influence the types of toxic effects that occur. Toxicology refers to the study of these adverse effects.

7.1.1 Dose-Response Relationship

Any chemical, when administered in sufficient quantities, is capable of producing an adverse effect. Dose-response is the measurable relationship between the dose of a chemical and a toxic effect caused by the chemical and is the most fundamental concept in toxicology. Data based on this concept allow for the regulatory classification of toxic chemicals

Dose is the amount of a toxic substance that is absorbed by an individual. Dose is reported as mass of substance [usually in milligram (mg) of chemical administered] per mass of body weight [usually in kilogram (kg) of body weight of the test animal]. The dose to which an individual is exposed over time determines whether toxic effects occur and the severity of the effects.

The dose-response relationship can provide important information about the chemical of interest. First it may be possible to define a threshold limit for the chemical, which is the smallest dose possible of eliciting a response. Secondly the dose-response relationship may be able to define the dose (or concentration) that produces a 50% response. This response is known as the LD50 or lethal concentration 50 (LC50) and is a statistically-estimated value. These values are commonly reported. On this basis, comparisons of relative potency amongst chemicals can be made.

The LD50 (median lethal dose) is the estimated single dose of material which, based on laboratory tests, is expected to kill 50% of a group of test animals. The material may be administered orally or applied to the skin. The LD50 dose is usually expressed as milligrams or grams of material per kilogram of animal body weight (mg/kg or g/kg).

The LC50 (median lethal concentration) is the calculated concentration of a material in air, which, based on laboratory tests (respiratory route), is expected to kill 50% of a group of test animals when administered as a single exposure in a specific time period, usually one hour. The LC50 can be expressed in several manners:

- as parts of material per million parts of air by volume (ppm) for gases and vapors;
- as micrograms of material per liter of air (mg/l); or

- as milligrams of material per cubic meter of air (mg/m3) for dusts and mists, as well as for gases and vapors.

7.1.2 Toxicokinetics

Toxicokinetics refers to the disposition of chemicals in the body. All chemicals have the potential to cause toxic effects. For a chemical to have a toxic effect, it must first come in contact with the body. The passage through biological membranes is called absorption. Once the chemical has entered the body, toxic effects may only occur if the chemical is distributed to other sites. Normal bodily functions attempt to remove foreign materials. Biotransformation or metabolism is the process by which living organisms can chemically change a substance. The new substance, or metabolite, may be more or less toxic than the original chemical. Finally chemicals or their metabolites are either stored in body systems or they are excreted via the kidney (urine), liver (bile/feces), or lungs.

7.1.3 Factors Affecting Response to Toxic Chemicals

The physical and chemical properties of a chemical, route of entry, dose, as well as the frequency and duration of exposure, are important factors to consider when assessing chemical exposure.

7.1.3.1 Chemical and Physical Properties of Material

A physical property of a substance is one that can be measured or observed without affecting the composition of the substance and include properties such as melting point, freezing point, density, solubility, vapor pressure, and the physical state (solid, gas, liquid). In contrast, properties that describe how a substance changes into a completely different substance are called chemical properties. Flammability, heat of combustion, reactivity with water, pH and corrosion/oxidative resistance are examples of chemical properties. Chemical and physical properties affect the potential toxicity of a chemical including how they enter the body, and once absorbed, the transport within the body.

7.1.3.2 Exposure Situation

The exposure situation refers to the dosage (how much), frequency (how often), duration (for how long) and route of exposure. An acute exposure is characterized by a single exposure to a relatively high dose of a hazardous chemical with a short duration of exposure. Chronic or repeated exposure to a chemical is characterized by repeated exposure, generally to a dose below which acute effects are observed, for a long duration of days, months or even years. Chronic exposure may result in bioaccumulation such as seen in heavy metal poisoning. This occurs when an individual is exposed to a toxic chemical and then exposed again before recovering from the previous exposure by means of metabolism or excretion. The chemical accumulates in tissues at concentrations higher than concentrations found in the surrounding environment.

7.1.3.2.1 Routes of Exposure (Entry into the Body)

The route of entry is the path by which a chemical enters the body. The type of toxic effects that are observed and their time of onset are affected by the route of entry. Chemicals may have serious effects by one route and minimal effects by another. For example, a chemical that is

ingested may cause different toxic effects than if it was absorbed through the skin. The route of entry may also determine whether local or systemic effects are observed. Laboratory personnel working with chemicals must be aware of possible routes of entry and should implement procedures and practices that reduce their risk of exposure.

7.1.3.2.1.1 Skin and Mucous Membrane Contact

A common way for chemicals to enter the body is through direct contact with the skin or a mucous membrane, such as your eyes. Skin contact with a chemical may result in a local effect, such as a burn or rash at the site of contact or the chemical may be absorbed into the bloodstream and cause systemic effects at distal sites in the body. The use of gloves, lab coats, eye protection, and other PPE can reduce the risk of skin and eye contact in the laboratory.

7.1.3.2.1.2 Inhalation

Inhalation is the most common route of entry for chemical vapors and aerosols. For some chemicals, depending on the vapor pressure and the temperature of the chemical, volatilization may occur, thus creating a potential for inhalation to occur.

The term *vapor* refers to the gas phase of a solid or a liquid substance at standard temperature and pressure. Vapor will revert to a solid or liquid phase by an increase in pressure or a decrease in temperature. Substances with low boiling points volatilize quickly into vapor. Examples include mercury, benzene, and methanol.

The term *aerosol* refers to liquid and solid particles suspended in a gaseous medium. Aerosols can contain droplets of hazardous chemicals, dust, fumes, biological materials, or other hazardous substances, and can remain suspended in the air for long periods of time. Small aerosol particles, if inhaled, may penetrate deep within the respiratory tract. The following activities can produce aerosols: centrifugation, homogenization (e.g., use of a blender, sonicator, grinder, or mortar and pestle), mixing, vortexing, or stirring, use of a separatory funnel, and pipetting.

Inhaled substances may cause localized effects on the lungs or be absorbed into the bloodstream, causing systemic effects.

7.1.3.2.1.3 Ingestion

Although direct ingestion of a laboratory chemical is unlikely, an individual may ingest contaminated food or beverages, touch the mouth with contaminated fingers, or swallow inhaled particles which have been cleared from the respiratory system. Direct ingestion may occur as a result of the outdated and dangerous practice of mouth pipetting. The risk of ingesting hazardous chemicals may be reduced by not eating, drinking, smoking, applying cosmetics, or storing food in the laboratory, and by washing hands thoroughly after working with chemicals even when gloves were worn.

7.1.3.2.1.4 Injection

A chemical can be injected into some parts of the body including skin, muscle, body cavities, or directly into the blood stream. Injection may result from a needlestick or puncture with a contaminated sharp object such as broken glass. In an injection exposure, the chemical may enter directly into the bloodstream and cause both local and systemic effects. Safety procedures for handling sharps in the laboratory should be instituted to reduce the risk from an injection of a hazardous substance.

7.1.3.3 Individual Factors

Individual susceptibilities play a significant role in the effects observed as a result of exposure to hazardous chemicals. Factors such as the age of exposed persons, the genetic background, as well as the health of an employee, including preexisting medical conditions, may affect the response to toxic chemicals. For example, laboratory personnel allergic to a sensitizing agent or allergen may experience adverse effects while those who are not allergic may not experience any adverse effect. Other individual factors such as pregnancy, smoking status, or general health status may exacerbate the exposure effect. Laboratory personnel should be familiar with the health hazards associated with toxic chemicals prior to use and should discuss their concerns with EHS or their healthcare provider.

7.1.3.4 Chemical Interactions

People are never exposed to only one chemical at a time and simultaneous exposure to other hazardous substances may interact in the body to produce responses that are different than if exposed independently. These interactions may result in increasing the toxic response (additive effect, synergistic effect, potentiating effect), decreasing the toxic response (antagonistic effect), or not affecting the toxic response (independent effect) of the individual chemicals

7.1.4 Classifications of Toxic Effects

Hazardous substances can produce many general types of toxic effects. Generally, exposure to hazardous substances may cause discomfort and lead to the development of exposure symptoms. The following list is by no means comprehensive, and the SDS for the particular substance should always be consulted to determine specific exposure symptoms associated with exposure to the chemical. All laboratory personnel should be able to recognize the following symptoms of a chemical exposure:

- Headache;
- Difficulty breathing or shortness of breath;
- Increased mucous production;
- Irritation or watering of the eyes;
- Irritation of the nose or throat;
- Confusion, dizziness, drowsiness, or loss of consciousness;
- An unfamiliar chemical odor;
- Irritation, rash, or discoloration of the skin;
- Unusual muscle cramps or joint pain; or

- Nausea.

If any of these symptoms (or symptoms identified by the SDS) occur, laboratory personnel should notify other personnel, evacuate the laboratory, and discontinue work until proper arrangements are made to prevent exposure.

Certain chemicals are more likely than others to cause a toxic effect and the degree of toxicity varies from chemical to chemical. Laboratory personnel should be aware of the toxicity of the chemicals used in the laboratory and precautions that should be implemented to prevent exposure. Information about the toxicity of a chemical may be found in the SDS provided by the manufacturer, on product labels, and from the *NIOSH Pocket Guide to Chemical Hazards* available on the EHS website. A mixture of toxic chemicals should be considered more toxic than its most toxic component.

7.1.4.1 Allergic Reactions

Allergic reactions, including hypersensitive and sensitization reactions, result from the body's production of antibodies in response to an allergens. This includes the production of antigens, which could result in an asthma attack, or mediation via specialized immune cells in response to a substance, which could result in a localized rash or discoloration at the point of contact.

7.1.4.2 Immediate or Acute Toxicity

Immediate or acute toxicity occurs rapidly after a single exposure. Examples of acute toxicity include: eye and skin burns from corrosives, eye and skin irritation, and asphyxiation.

7.1.4.3 Delayed or Chronic Toxicity

Delayed or chronic toxicity manifests itself after a period of latency (may be many years). Chronic toxicity is generally characterized by adverse health effects as a result of repeated exposure to a low dose (typically below concentrations where acute effects are observed) over a long period of time. Long term exposure to chemicals can result in localized or systemic damage. Carcinogens, reproductive toxins, and some solvents are chemical substances that have high chronic toxicity. OSHA 29 CFR 1910 Subpart Z provides specific requirements for how to monitor and control exposure to chemicals with high chronic toxicity. Examples of chemicals of high chronic toxicity include organomercurial compounds, benzo[a]pyrene, N-nitrosodiethylamine, toluene, and xylene.

7.1.4.4 Reversible or Irreversible effects

Reversible effects are those adverse effects that wear off (or reverse), given sufficient time after the exposure ceases. Irreversible effects are those adverse effects that do not reverse after the exposure ceases. The damage is permanent.

7.1.4.5 Local Toxicity or Systemic Toxicity

Local toxicity occurs at the site of chemical contact. The chemical need not be absorbed to cause this reaction. Examples include skin and eye irritation and respiratory tract irritation. Systemic

toxicity occurs at a site or sites distant from the site of chemical absorption. Most chemicals produce systemic toxicity following absorption. Some chemicals may cause both local and systemic toxicity. For example, hydrofluoric acid may cause local corrosive burns as well as reacting with calcium in bone.

7.1.5 Adverse Health Effects

7.1.5.1 Irritation

Irritation to toxic substances may occur as a result of skin, eye, or inhalation exposure. Laboratory personnel may experience localized irritation as a result of exposure; absorption of the chemical may also result in systemic effects. Examples of irritants include ammonia, hydrochloric acid, halogens, acetic acid, and formaldehyde.

7.1.5.2 Sensitization

Sensitization is an immune response to hazardous substances in susceptible individuals. Physiological responses to these substances vary from person to person, ranging from skin disturbances to anaphylactic shock or even death. It is possible to be allergic to a variety of substances and chemicals. The SDS indicates whether a chemical is known to be a sensitizer. Individuals who are sensitized to a chemical experience a relatively normal reaction to a sensitizing agent the first time they are exposed to the agent. The initial reaction may include irritation at the site of contact if the chemical is known to be an irritant. Subsequent exposure to the sensitizing agent or to a structurally similar agent will induce an allergic response. The allergic reaction may be observed at concentrations below which prior exposure did not result in adverse effects. Subsequent exposure to the sensitizing agent (or one that is structurally similar) typically results in a progressively severe allergic response. A few examples of laboratory substances that cause allergic reactions include metals (e.g., platinum, nickel, chromium, beryllium, cobalt), latex, and formaldehyde.

7.1.5.3 Asphyxiation

Asphyxiation is oxygen deprivation due to oxygen displacement in the environment or due to chemical effects on the body. Simple asphyxiants are inert gases which displace oxygen in the environment. Examples of simple asphyxiants include nitrogen, carbon dioxide, and helium. Chemical asphyxiants are chemicals which prevent the uptake of oxygen by the cells. Examples are carbon monoxide, hydrogen sulfide, and cyanides. For chemicals asphyxiants, there may be adequate oxygen supply in the environment, but hemoglobin has such a high affinity for chemical asphyxiants that the chemical asphyxiants are absorbed in the blood instead of oxygen. As a result, the organ systems are also deprived of oxygen.

7.1.5.4 Target Organ Toxicity

Once chemicals are taken into the body and absorbed they may travel via the blood stream to a target organ (systemic effect). Target organs are those organs of the body that are most affected by exposure to a particular chemical. The affinity of the chemical to a particular organ or organ system is dependent on the physical and chemical properties of the chemical and the organ.

7.1.6 Particularly Hazardous Substances

Particularly Hazardous Substances have been identified by OSHA as requiring special consideration and additional safety provisions because of their toxic effects. This includes select carcinogens, reproductive toxins, and chemicals with a high degree of acute toxicity. (This information can be obtained from the SDS for the chemical in question.) Projects involving these hazardous substances should be reviewed to determine appropriate safety measures for use, storage, and disposal of these substances. As part of the *Supplemental Laboratory Safety Plan*, PI/LS are required to provide the following information for Particularly Hazardous Substances: location of designated areas where Particularly Hazardous Substances are used or stored, types of containment devices used to work with the substances, and decontamination waste handling procedures. If it is determined that a chemical in the laboratory poses an identifiable risk to personnel and is not discussed in this manual, it should undergo a similar review process to evaluate the protection provided. To safely manage toxic chemicals, consult the SDS and adhere to the recommended storage and usage procedures outlined in both the SDS and in this manual.

7.1.6.1 Select Carcinogens

A carcinogen is any chemical which has the potential to cause cancer in humans. Select carcinogens are those substances regulated by OSHA as a carcinogen (29 CFR 1910.1003) as well as substances listed under the category "known to be carcinogens" in the *Annual Report on Carcinogens* published by the National Toxicology Program (latest edition) or under Group 1, 2A, or 2B by the IARC Monographs (latest edition).

The carcinogenic properties of many chemicals have not been tested. If the carcinogenic properties of a chemical are unknown, it must be assumed that low doses of the chemical could potentially cause cancer, but at a slower rate than high doses. For carcinogenic chemicals, assume that an effect occurs at any dose, even if not readily observable. Exposure to several carcinogens at once may result in cancer rates higher than would be expected by adding the risks from each carcinogen separately. Therefore, it is prudent to reduce exposure to chemicals to the lowest level possible. Specific regulations governing the use of these chemicals can be found at www.osha.gov.

7.1.6.2 Reproductive Toxins

Reproductive toxins, as defined by OSHA, are chemicals which affect reproductive capabilities, including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of offspring. Reproductive toxicity refer to chemicals known as mutagens as well as chemicals that have adverse effects on sexual function and fertility, and teratogens; chemicals that have adverse effects on development of the offspring. Mutagens cause mutations or permanent changes in the amount or structure of the genetic material within a cell and may be genetically inheritable to offspring. Reproductive toxins classified as to the adverse effects on sexual function and fertility include those that cause alterations to: the reproductive system, onset of puberty, gamete production and transport, reproductive cycle normality, sexual behavior, fertility, and pregnancy outcomes. Reproductive toxins, including teratogens, are classified by the adverse effect on development of offspring and include any effect of a chemical which interferes with normal development of the organism either before or

after birth which is induced during pregnancy from parental exposure. They may include death of the developing organism, structural abnormality or altered growth or functional deficiency. The period of greatest fetal susceptibility to reproductive toxins is the first eight-to-12 weeks of pregnancy, which includes the period when a woman may not know she is pregnant.

Some examples include: ethylene dibromide and dibromochloropropane which are known to cause sterility in males; exposure of males to vinyl chloride has been associated with miscarriages in their partners. Reproductive toxins that are typically found in laboratories include formamide and formaldehyde. More information regarding reproductive toxins is available in the NIOSH publications: *The Effects of Workplace Hazards on Female Reproductive Health* and *The Effects of Workplace Hazards on Male Reproductive Health*.

7.1.6.3 Chemicals with a High Acute Toxicity

Chemicals with high acute toxicity (Category 1) have an oral LD50 of ≤5 mg/kg, a dermal LD50 of ≤50 mg/kg, or an inhalation LC50 of ≤100ppm. The LD50 is the quantity of material that when ingested, injected, or applied to the skin as a single dose will cause death of 50% of exposed test animals. The test conditions should be specified, such as length of exposure and concentration of the chemical. The LD50 value is expressed in grams per kilogram (g/kg) or milligrams per kilogram (mg/kg) of body weight. Chemicals with high acute toxicity can cause immediate adverse health effects in a relatively short time after a single concentrated low dose. SDS information must be evaluated to determine if a chemical is acutely toxic. Acutely toxic chemicals, such as arsine, diborane, fluorine, hydrogen cyanide, phosgene, nitric oxide, and allylamine, can pose a serious inhalation hazard and warrant the evacuation of a room or building if they begin leaking or have the potential to rupture.

7.2 Hazards of Chemicals

Hazardous chemicals possess a spectrum of physical and chemical properties that must be understood before beginning work in a laboratory. Hazardous chemicals include explosive chemicals, compressed gas cylinders, flammable chemicals, reactive chemicals, oxidizing chemicals, organic peroxides, corrosive chemicals, cryogenic liquids, and dry ice.

7.2.1 Explosive Chemicals

Explosive chemicals are chemicals that cause a sudden, almost instantaneous release of pressure, gas, and heat when subject to shock, pressure, or high temperature. Because of the hazards associated with explosive chemicals, George Mason University prohibits the acquisition or purposeful production of explosive chemicals. Examples of explosive chemicals include ammonium nitrate; ammonium perchlorate; barium azide; diazodinitrophenol; diethyleneglycol dinitrate; dinitrophenolates; 2, 4 dinitrophenylhydrazine; lead styphnate; nitrourea; nitrocellulose; sodium picramate; tetranitroanaline; and trinitrophenol (dry picric acid).

In addition to inherently explosive chemicals, some laboratory chemicals become potentially explosive if managed incorrectly. These chemicals, under certain conditions (gentle heat, light, mild shock, or chemical reaction) have the potential to undergo explosive reactions. For example, acetylides, azides, metal salts of nitrophenols, organic nitrates, multi-nitrated

compounds, and organic peroxides become shock sensitive over time as they begin to dry or are mixed with metal oxides. Picric acid and picrylchloride become explosive if not sufficiently hydrated. To prevent laboratory chemicals from becoming explosive, consult the SDS and adhere to the recommended storage and usage procedures outlined in both the SDS and this manual. EHS should be contacted immediately if an explosive or potentially explosive chemical is discovered in the laboratory.

7.2.2 Compressed Gas Cylinders

Hazards associated with gas cylinders include those hazards inherent to the chemical they contain and the physical hazards associated with maintaining the gaseous form of that chemical under pressure. Cylinders may contain flammable, corrosive, poisonous, inert, or acutely toxic gases that exhibit a variety of toxic effects. In addition, a leaking cylinder may have the potential to rupture. To safely manage cylinders, consult the SDS and adhere to the recommended storage and usage procedures outlined in both the SDS and in this manual.

7.2.3 Flammable Chemicals

Liquids with a flashpoint ≤93°C (200°F) are considered flammable chemicals. The flashpoint of a chemical is the minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid. Alcohols and organic solvents are the most common flammable chemicals used in the laboratory. To safely manage flammable liquids, consult the SDS and adhere to the recommended storage and usage procedures outlined in both the SDS and in this manual.

An acute exposure to very high concentrations of organic solvents can cause unconsciousness and death. Chronic exposure can cause nausea, headaches, fatigue, and mental impairment. Injury to the organs of the body and damage to the blood may also occur. Studies have shown that low concentrations of common laboratory solvents in the air can adversely affect behavior, judgment, and coordination. Contact with the skin may cause irritation, dermatitis, or an allergic reaction. Some solvents, such as benzene and xylene, may be absorbed through the skin and enter the bloodstream.

7.2.4 Reactive Chemicals

Reactive chemicals react violently with water, air, or other chemicals to produce toxic gases, heat, fire, or explosion. Examples include metal hydrides, pyrophorics, water reactive chemicals, borohydrides, borane complexes, anhydrides, calcium, sodium, and metal powders. To safely manage reactive chemicals, consult the SDS and adhere to the recommended storage and usage procedures outlined in both the SDS and in this manual.

7.2.4.1 Air and Water Reactive Chemicals

Air reactive chemicals (also called pyrophoric chemicals) ignite spontaneously within five minutes after coming in contact with air. Examples of air reactive chemicals are: tert-Butyllithium, silanes, alkyl metal derivatives, fine metal powders, metal hydrides, sodium methoxide, triethylaluminum, and white phosphorous.

Water reactive chemicals combine with water or moisture in the air to produce heat, ignite, or form explosive or toxic gases. These chemicals present a severe fire hazard because a sufficient amount of heat is often released to promote auto-ignition or to ignite surrounding materials. These chemicals can react spontaneously and rapidly even in controlled environments. Contact with the skin can cause severe burns. Examples of water reactive chemicals include: alkaline-earth metals (e.g., sodium, lithium, calcium), aluminum chloride, anhydrous metal halides, anhydrous metal oxides, and nonmetal oxides.

7.2.4.2 Peroxide-Forming Chemicals

Compounds such as ethyl ether and tetrahydrofuran, can form unstable peroxides if managed or stored improperly. The formation of explosive peroxides can be accelerated by the introduction of contaminants, particularly metal oxides and oxygen, and exposure to heat and light. The development of crystals inside a bottle or around a cap or a cloudy appearance is indicative of peroxide formation. Do not attempt to move or handle the container. If a container that contains a peroxide-forming chemical exhibits these characteristics, has remained in storage beyond the expiration date, or has been open for longer than twelve months, contact EHS to manage disposal of the container.

7.2.4.3 Temperature-Sensitive Chemicals

Improper storage of temperature-sensitive chemicals can result in a boiling liquid expanding vapor explosion (BLEVE) that can violently rupture the container. Additionally, the product involved in a BLEVE may be reactive, flammable, or harmful to health, thereby increasing the hazards and consequences to health and safety. Temperature-sensitive chemicals should never be allowed to remain outside of a temperature-controlled environment for any period of time longer than necessary to dispense or transport the chemical. If the chemical is no longer needed, leave the chemical in controlled climate storage and contact EHS to make disposal arrangements.

7.2.4.4 Multi-nitrated Chemicals

Some multi-nitrated chemicals decompose violently when subjected to shock, heat, or other chemicals. Most multi-nitrated chemicals become more sensitive to shock and temperature when they become dry. Picric acid (phenol trinitrate or trinitrophenol) and 2,4-dinitrophenylhydrazine are examples. Typically, these chemicals are manufactured and shipped with at least 30% water by weight. To prevent loss of water, containers must be kept tightly sealed. Containers should be inspected before each use to determine if the chemical has become dehydrated or if crystallization has occurred. If the chemical has become dehydrated or crystallization has occurred, the container should not be moved and EHS should be contacted immediately.

7.2.5 Oxidizing Chemicals

An oxidizing chemical will cause a substantial increase in the burning rate of a combustible material with which it comes in contact; undergo vigorous self-sustained decomposition when catalyzed or exposed to heat; or cause spontaneous ignition of a combustible or flammable chemical with which it comes in contact. Strong oxidizing chemicals will react with solvents, wood, and fine metal powders. Examples of strong oxidizers include nitric, chromic, and

sulfuric acids, chromates, perchlorates, nitrates, permangenates, persulfates, and peroxides. To safely manage oxidizing chemicals, consult the SDS and adhere to the recommended storage and usage procedures outlined in both the SDS and in this manual.

7.2.6 Organic Peroxides

Organic peroxides are extremely flammable and many are more sensitive to detonation than primary explosives such as trinitrotoluene. Due to their sensitivity to shock, heat, and sparks, special consideration should be given to use of these compounds.

Organic peroxides can be safely used in laboratory activities. Inert solvents such as aliphatic hydrocarbons can be added to organic peroxides to reduce their sensitivity to shock. However, avoid aromatic solvents due to their tendency to induce diacyl peroxide decomposition. Additional consideration should be given to solvents used in organic peroxide manipulations and solutions. Volatile solvents can evaporate and result in increased peroxide concentration. Always clean equipment prior to using and after using organic peroxides. Examples of organic peroxides include benzoyl peroxide, ketone peroxides, peroxydicarbonates, and peroxyacids. To safely manage organic peroxides, consult the SDS and adhere to the recommended storage and usage procedures outlined in both the SDS and in this manual.

7.2.7 Corrosive Chemicals

Corrosive chemicals are acids and bases that cause severe tissue damage at the site of contact. Exposure to these chemicals can burn the skin or cause severe bronchial irritation or blindness. Strong acids are chemicals with a pH less than two (e.g., butyric acid, formic acid, glacial acetic acid, hydrochloric acid, nitric acid, sulfuric acid, perchloric acid, and phosphoric acid). Concentrated acids react violently with bases, and can react with other acid sensitive chemicals (e.g., alkali metals, hydroxides, carbonates, carbides, arsenic, cyanides, sulfides, and most metals) to produce heat or dangerous gases. Acids pose the additional hazard of being very slippery when spilled.

Hydrofluoric acid is extremely hazardous due to the high affinity of the fluoride anion to the elemental calcium in the bones and body tissues resulting in hypocalcaemia. Inhalation of anhydrous hydrogen fluoride can be fatal. The effects of hydrofluoric acid exposure can be treated with calcium gluconate gel or benzalkonium chloride solution which acts to neutralize hydrofluoric acid before it can react with calcium in the body, specifically bone. Laboratories that use or store hydrofluoric acid are required to have calcium gluconate or benzalkonium chloride solution on hand in the event of an exposure. Spills involving hydrofluoric acid may not be handled by laboratory personnel. EHS should be contacted immediately to arrange for appropriate spill response, as these spills must be managed by a trained professional.

Strong basic or caustic chemicals have a pH greater than 12.5 (e.g., sodium hydroxide, potassium hydroxide, amines, and ammonium hydroxide). Basic chemicals react dangerously with acids and oxidizing chemicals and must be segregated from these chemicals. For example, when ammonium hydroxide and sodium hypochlorite (bleach) are mixed, chlorine gas is released. To safely manage corrosive chemicals, consult the SDS and adhere to the recommended storage and usage procedures outlined in both the SDS and in this manual.

7.2.8 Ototoxic Chemicals

Epidemiologic studies and case reports suggest that exposure to some ototoxic chemicals, alone or simultaneously with noise, may result in hearing loss. There is time-weighted average (TWA) for simultaneous exposure to ototoxins and noise, but an evaluation should be conducted by EHS when personnel are exposed to ototoxins including lead, manganese, styrene, toluene, and xylene. Employees exposed to air concentrations of ototoxic chemicals in excess of half the OSHA PEL for the chemical shall be enrolled in the Medical Surveillance Program.

7.2.9 Cryogenic Liquids

Cryogenic liquids are chemicals with boiling points lower than -150˚C (-238˚F). Common cryogenic liquids are helium, oxygen, hydrogen, and nitrogen. Contact with cryogenic liquids can cause severe tissue damage (e.g., frost bite and thermal burns). Even very brief contact with a cryogenic liquid is capable of causing tissue damage.

Vessels containing cryogenic liquids are subject to extreme pressure and must have a spring-loaded relief valve. (Use of a rupture disk as a means of emergency pressure relief is unacceptable.) Adequate ventilation must always be used to prevent the build-up of vapors and flammable gases such as hydrogen, methane, and acetylene. All cryogenic liquids, in sufficient quantities and in poorly ventilated areas, have the ability to displace oxygen and create an oxygen-deficient atmosphere. Chemicals such as oxygen pose an additional fire hazard by creating an oxygen rich environment that can support combustion. Liquid nitrogen should not be used to cool a flammable mixture in the presence of air because oxygen can condense from the air and lead to a potentially explosive condition.

7.2.10 Dry Ice

Dry ice sublimates to gaseous carbon dioxide. Carbon dioxide is a colorless odorless gas which is heavier than air and can accumulate in poorly ventilated areas. Carbon dioxide is a simple asphyxiant, a chemical that displaces oxygen and may create an oxygen-deficient atmosphere when present in high concentrations. Direct contact with dry ice can cause severe thermal burns. Dry ice should not be stored in refrigeration units.

8.0 Hazardous Materials Procurement

DOT regulates shipping and transport of hazardous materials and mandates specific requirements for:

- Training of individuals who are designated as hazardous materials employees and in the scope of their duties ship, transport, or handle hazardous materials;
- Packaging, labeling, and transporting materials;
- Documentation of shipments of hazardous materials; and
- Reporting of damaged or lost packages or other incidents that occur during shipping.

A hazardous material, as defined by DOT, is, "a substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported." This includes hazardous chemicals, infectious materials, and radioactive materials.

The EHS *Hazardous Materials Shipping and Receiving Guide* provides information for university personnel who are not designated as hazardous materials employees and are not required to receive specific DOT training, but may sign for or receive packages containing hazardous materials, or need hazardous materials shipped on an infrequent basis.

Laboratory personnel who receive hazardous materials for research or instructional purposes must be aware of George Mason University and government regulations regarding the type and quantity of materials they are permitted to receive; and should review the EHS *Hazardous Materials Shipping and Receiving Guide* and receive appropriate hazard communication training.

Compliance requirements for acquiring and working with hazardous material depend on the type of material and its potential hazard. Access to certain material may require the recipient to apply for a permit, license, or registration. George Mason University requires a MTA be in place when acquiring or transferring materials to or from another institution or investigator. Contact OSP for more information.

This manual provides information on the proper ordering, receipt, transport, and shipping of hazardous chemicals according to relevant governmental regulations and George Mason University policies. The *Biological Safety Manual* and *Radiation Protection Plan* address procurement, shipping, and transport of infectious materials and radioactive materials, respectively.

8.1 Ordering Hazardous Materials

Before a chemical is ordered, consideration should be given to the properties of the chemical, storage, and security. Proper storage facilities and safety equipment should be available prior to acquisition of the chemical. Chemicals should be ordered in quantities that will be used within 18 months of receipt and for which there is proper storage.

Not all hazardous materials are permitted on George Mason University property. Prohibited materials include explosive materials, Risk Group 4 infectious agents, and radioactive materials not permitted under radioactive materials license issued to George Mason University by the Virginia Department of Health. (Refer to the *Radiation Protection Plan* for more information.) If a hazardous materials transporter attempts to deliver a prohibited material, the package should not be accepted and EHS should be contacted immediately with the name of the vendor and the intended recipient.

The acquisition of certain materials is restricted at George Mason University and requires special authorization. Restricted materials include:

- **Substances regulated by the Drug Enforcement Agency (DEA**): A current DEA Controlled Substances Registration Certificate is required to order DEA-regulated substances. Additional restrictions on the use and storage of controlled substances are required by the DEA. Contact EHS for more information.
- **Select Agents and Toxins:** Select agents and toxins are specific biological materials that have been identified by the federal government as agents that have potential use in biological terrorism or warfare. PI/LS who wish to acquire, possess, use, or transfer select agents and toxins must notify EHS for assistance in registering with the CDC and/or APHIS and be in compliance with pertinent United States Department of Health and Human Services and/or United States Department of Agriculture regulations before these materials may be acquired. Contact EHS for more information regarding select agents and toxins.
- **Radioactive materials:** Radioactive materials orders must be placed and received by the Radiation Safety Officer or other designated EHS personnel. See the *Radiation Protection Plan* for more information.

8.1.1 Purchasing Tax-Free Alcohol

Grain alcohol, ethanol 95% or greater, is used for a variety of applications in research. To purchase and use grain alcohol tax-free, two permits are required: an Industrial Alcohol User Permit issued by the Alcohol and Tobacco Tax and Trade Bureau (TTB) of the Department of Treasury, and a permit to purchase and transport alcohol issued by the Virginia Department of Alcohol Beverage Control (ABC). EHS maintains George Mason University's Industrial Alcohol User Permit. Individual units or departments must obtain Permits to Purchase and Transport Alcohol from the ABC. These permits are only required for the tax-free purchase of alcohol. The following steps must be followed to order and manage inventory of grain alcohol:

- In order to purchase grain alcohol, the person placing the order must possess both an ABC Permit to Purchase and Transport Alcohol for their department and a copy of George Mason University's TTB Industrial Alcohol User Permit. Instructions for purchase of grain alcohol are provided in *Purchasing and Storage of Grain Alcohol Guide* the EHS website.
- Upon receipt of a package of alcohol, the package should be inspected for any damage. If there is any evidence of leakage, the Chemical Hygiene Officer should be contacted. The outside of the package should be dated with date of receipt.

- All grain alcohol should be placed in a secure and lockable flammable storage cabinet. . This cabinet should be kept locked except when accessing material.
- A written continuous log on material in storage should be maintained. The quantity and date of receipt should be recorded in the log when the alcohol is first placed into storage. When a new container of alcohol is needed, the size of the container and the date of receipt of alcohol removed from the flammable storage locker should be noted on the log. The date when the container is first opened should be noted on the outside of the container. In order to maintain an accurate inventory, grain alcohol should not be shared with other laboratories.
- Opened containers should be returned to the flammable storage cabinet when not in use.
- Empty containers should be disposed of with regular laboratory refuse. All labels should be removed or the contents should be conspicuously marked out with an indelible marker.

8.2 Receiving Chemicals

All hazardous materials shipped to George Mason University from a vendor or transferred from another institution must be packaged and transported in accordance with requirements set forth by DOT or International Civil Aviation Organization (ICAO).

Laboratory personnel should examine packages before they are accepted. Any packages that are improperly labeled; contain prohibited materials; or show signs of damage, tampering, or leakage should not be accepted. The hazardous materials transporter should be directed to remain onsite with the package and EHS should be contacted. Unknown or suspicious packages should be reported to University Police.

Packages that contain hazardous materials must meet specific labeling requirements that convey the hazards associated with the package contents and appropriate handling procedures. DOT has established symbols (DOT placards) that represent various classes of hazardous materials (Table 1).

Under most circumstances, these symbols must appear on packages containing hazardous material along with the complete chemical name, United Nations (UN) number, and a packing list (if the package contains multiple items). Exceptions to labeling requirements are made for certain hazardous materials packages, based upon the quantity of hazardous material being shipped. It is possible that a package could contain a small amount of hazardous material without a hazard class label. For this reason, all packages that contain chemicals should be handled as if they contain hazardous materials.

Once a package is accepted, it should remain in the original packaging and be kept in a secure area until delivered to the laboratory or storage area. Hazardous materials should be labeled with the delivery date as soon as they are opened and an SDS for the chemical should be placed in the *SDS Library* if not already present.

8.2.1 Chemicals Requiring Special Consideration

Organic peroxides, reactive materials, peroxide-forming compounds, and chemicals that pose an inhalation hazard should be ordered in quantities that can be used within three-to-six months. Upon receipt, these chemicals must be immediately transferred to an appropriate storage area.

Packages containing biological materials should remain in the original packaging and be kept in a secure area until they can be opened using appropriate PPE and containment. The dry ice in biological material packages should be placed in a chemical fume hood to sublime. Never place dry ice into a laboratory sink, as it may cause pipes to rupture.

Table 1. DOT Hazard Class Diamonds for Chemicals

DOT Placard	Placard Description
	**EXPLOSIVE (Class 1):** Any substance or article (including a device) which is designed to function by explosion (i.e., an extremely rapid release of gas and heat) or which, by chemical reaction within itself, is able to function in a similar manner even if not designed to function by explosion. Receiving of all Class 1 hazardous materials are prohibited at George Mason University with the exception of the police department.
	**FLAMMABLE GAS (Division 2.1):** Any material which is a gas at 20°C (68°F) or less and 101.3 kPa [14.7 pounds per square inch (psi)] of pressure which:(1) Is ignitable at 101.3 kPa (14.7 psi) when in a mixture of 13% or less by volume with air; or (2) has a flammable range at 101.3 kPa (14.7 psi) with air of at least 12%, regardless of the lower limit.
	**OXYGEN (Division 2.2)**: Compressed, in cylinders.
	**NON-FLAMMABLE GAS (Division 2.2):** Any material (or mixture) which (1) exerts in the packaging an absolute pressure of 280 kPa (40.6 psi absolute) or greater at 20°C (68°F), and (2) does not meet the definition of a flammable or poison gas. (Including compressed gas, liquefied gas, pressurized cryogenic gas, compressed gas in solution, asphyxiant gas, and oxidizing gas.)
	**POISON GAS (Division 2.3):** A material which is a gas at 20°C (68°F) or less and a pressure of 101.3 kPa (14.7 psi) and that: (1) is known to be so toxic to humans as to pose a hazard to health during transportation, or (2) in the absence of adequate data on human toxicity, it is presumed to be toxic to humans when tested on laboratory animals and has an LC50 value of not more than 5,000 ml/m^3.
	**FLAMMABLE LIQUID** (Class 3): A liquid having a flash point of not more than 60°C (140°F).

	**FLAMMABLE SOLID** (**Division 4.1**): Any of the following three types of materials:(1) **Desensitized explosives**, (2) **Self-reactive materials** are materials that are thermally unstable and that can undergo a strongly exothermic decomposition even without participation of oxygen (air), (3) **Readily combustible solids** are materials that: (i) Are solids which may cause a fire through friction, such as matches; (ii) Are powdered, granular, or pasty materials which show a burning rate faster than 2.2 milimeters (mm) (0.087 inches) per second or less than 45 seconds, when tested in accordance with UN Manual of Tests and Criteria, and (4) **Any metal powders** that can be ignited and the reaction spreads over the whole length of a sample in 10 minutes or less.
	**SPONTANEOUSLY COMBUSTIBLE** (**Division 4.2**)**:** (1) **A pyrophoric material**, which is a liquid or solid that, even in small quantities and without an external ignition source, can ignite within five minutes after coming in contact with air when tested according to the UN Manual of Tests and Criteria, and (2) **A self-heating material**, which is a material that, when in contact with air and without an energy supply, is liable to self-heat. A material of this type exhibits spontaneous ignition or the temperature of the sample exceeds 200 °C (392 °F) during a 24-hour test period.
	**DANGEROUS WHEN WET** (**Division 4.3**)**:** A material that, when in contact with water, is liable to become spontaneously flammable or to give off flammable or toxic gas at a rate greater than 1 liter per kg of the material per hour.
	**OXIDIZER** (**Division 5.1**)**:** A material that may, generally by yielding oxygen, cause or enhance the combustion of other materials.
	**ORGANIC PEROXIDE** (**Division 5.2**)**:** Any organic compound containing oxygen in the bivalent structure and which may be considered a derivative of hydrogen peroxide, where one or more of the hydrogen atoms have been replaced by organic radicals.

	**POISONOUS (Division 6.1):** A material, other than a gas, which is known to be so toxic to humans as to afford a hazard to health during transportation, or which, in the absence of adequate data on human toxicity: (1) is presumed to be toxic to humans because it falls within any one of the following categories when tested on laboratory animals (whenever possible, animal test data that has been reported in the chemical literature should be used): (i) **Oral Toxicity**: A liquid with an LD_{50} for acute oral toxicity of not more than 500 mg/kg or a solid with an LD_{50} for acute oral toxicity of not more than 200 mg/kg, (ii) **Dermal Toxicity**: A material with an LD_{50} for acute dermal toxicity of not more than 1000 mg/kg, (iii) **Inhalation Toxicity**: (A) A dust or mist with an LC_{50} for acute toxicity on inhalation of not more than 10 mg/L; or (B) A material with a saturated vapor concentration in air at 20 °C (68 °F) of more than one-fifth of the LC_{50} for acute toxicity on inhalation of vapors and with an LC_{50} for acute toxicity on inhalation of vapors of not more than 5000 ml/m^3; (2) Is an irritating material, with properties similar to tear gas, which causes extreme irritation, especially in confined spaces.
	**Infectious Substances** (**Division 6.2):** Substances which are known or are reasonably expected to contain pathogens. Pathogens are defined as micro-organisms (including bacteria, viruses, rickettsiae, parasites, fungi) and other agents such as prions, which can cause disease in humans or animals. **Category A:** An infectious substance in a form capable of causing permanent disability or life-threatening or fatal disease in otherwise healthy humans or animals when exposure to it occurs. **Category B:** An infectious substance not in a form generally capable of causing permanent disability or life-threatening or fatal disease in otherwise healthy humans or animals when exposure to it occurs.
	**Radioactive Materials** (**Class 7**)**:** A material that exhibits a spontaneous change in its nuclear structure usually accompanied by emission of subatomic particles and/or ionizing radiation. The radiation can be alpha particles (helium nuclei), beta (positive or negative) particles (high speed positrons or electrons), or gamma (electromagnetic) radiation, or a combination of any two or all three.
	**CORROSIVE** (**Class 8**): A liquid or solid that causes full thickness destruction of human skin at the site of contact within a specified period of time or a liquid that exhibits a corrosion rate on steel or aluminum surfaces exceeding 6.25 mm (0.25 inch) a year at a test temperature of 55°C (130°F).
	**Miscellaneous (Class 9):** A material which presents a hazard during transport but which is not included in any other hazard class. This class includes any material which has an anesthetic, noxious, or other similar property which could cause extreme annoyance or discomfort, or any material which meets the definition of a hazardous substance or hazardous waste.

8.2.2 Damaged or Leaking Packages

If a hazardous materials transporter attempts to deliver a leaking package, the package must be rejected and EHS must be contacted. The hazardous materials transporter should be told to

remain on the premises until the package has been properly repacked and the spill, if one should occur, is properly contained and cleaned. Federal regulations mandate that hazardous materials transporters may not accept or ship a container that is leaking or does not meet specific federal regulations regarding hazardous materials packaging. The transporter or product manufacturer will bear the financial responsibility for cleaning up a spill and repackaging the material. If university personnel accept the material, George Mason University will bear all liabilities associated with chemical exposure, spill, and emergencies related to the leaking container. If a transporter attempts to leave George Mason University with a leaking hazardous materials container, contact EHS immediately and record the driver's name, company, and vehicle information (license plate number and state of issue).

9.0 Chemical Storage

Each laboratory must have adequate chemical storage areas that provide sufficient and defined barriers between incompatible chemicals. Information on proper chemical storage can be found in the SDS for each chemical. Proper storage of biological and radioactive materials can be found in the *Biological Safety Manual* and the *Radiation Protection Plan*, respectively.

Follow these guidelines when storing chemicals:

- Storage areas should be dry, well ventilated, and located away from sunlight and ignition sources.
- Chemicals should be stored in cabinets treated, coated or constructed of materials that are compatible with the chemicals being stored that have a lip or guard along the exposed edge.
- Cabinets should be easily accessible and clearly labeled as chemical storage areas by:
    - Using a pictogram of the primary hazard category contained in the cabinet;
    - A sign indicating that the cabinet contains chemicals;
    - See-through panes that allow visibility of the cabinets contents; or
    - Other marking that clearly indicates the storage of chemicals.
- Chemicals should be stored below eye level to minimize accidental exposure from spills.
- Solids should be stored above liquids.
- Chemicals must be segregated by chemical compatibility.
- Secondary containment should be used to segregate incompatible chemicals .and control spills for containers of hazardous liquids greater than 1.3 gallons (5L).
- Only limited quantities of chemicals should be stored in the laboratory.
- Storage areas should be inspected frequently to identify deteriorating containers and faded or missing labels.

9.1 Control Area and Maximum Allowable Quantity

In accordance with the SFPC, buildings that will contain hazardous materials are designed with control areas:

- Spaces within a building where quantities of hazardous materials not exceeding the maximum allowable quantities are:
    - Stored,
    - Dispensed, or
    - Used or handled.
- Constructed with fire resistance-rated walls and floors.

Table 2703.8.3.2 of the SFPC demonstrates the number of control areas permitted per floor and the required fire rating for walls separating control areas from each other, and other spaces not otherwise rated. Also illustrated is the percentage of the Maximum Allowable Quantity (MAQ) of hazardous substances allowed per control area on each floor above and below grade.

At George Mason University, the *Supplemental Laboratory Safety Plan* requires PI/LS to document facility-related limits on chemical storage. The MAQ per control area is an administrative control method used to regulate the maximum amount of a hazardous materials allowed to be stored or used within a control area inside a building based upon the physical state of the material and relevant storage conditions. Storage and use of hazardous materials in quantities that exceed the MAQ per control area require specified hazard class building construction to accommodate the additional hazards. Use of hazardous materials in excess of the MAQ is not permitted in buildings without hazard class construction as it constitutes a violation of the SFPC. Table 2703.1.1(1) and (2) of the SFPC demonstrates the MAQ per control area of hazardous materials posing a physical or health hazard (see Appendix C).

9.2 Container Labeling

OSHA requires that each chemical container, regardless of size or use, be properly labeled with the complete chemical name (formulas, abbreviations, and sketches of the molecule are not acceptable), manufacturer's information (if the chemical is in its original container), appropriate hazard information; words, pictures, symbols, or combination thereof, which provide at least general information regarding the hazards of the chemicals. If a chemical is transferred from the original manufacturer's container to a new container it must be clearly labeled using the complete chemical name and the associated hazards of the chemical. Chemical formulas or abbreviations are not sufficient.

The date received (for ordered chemicals) or the date generated (for chemical dilutions and experimental samples) should be recorded on all containers to prevent excessive waste and ensure proper disposal of expired chemicals.

Permanent ink should be used to label containers, and labels should be securely attached to the side of the container. Labels affixed to container lids or stoppers are not reliable for identifying chemicals because lids may inadvertently be switched during use.

Experimental samples and small reagent vessels may be identified by an alpha, numeric, or alphanumeric label as long as this label and corresponding label information is provided in a log that lists the chemical name represented by each sample and the hazards associated with that chemical. Laboratory personnel should be aware of the log and the hazards associated with the samples.

Unlabeled containers must be assumed to contain hazardous components until the contents can be identified. Contact EHS for assistance in handling unlabeled containers.

9.3 Chemical Compatibility and Segregation

To prevent unwanted or dangerous chemical reactions, chemicals must be stored according to compatibility. Chemicals of the same hazard classification or functional group that share the same characteristics may be stored together. Incompatible chemicals must be segregated. SDS and container labels provide useful information regarding compatibility and storage requirements. Container labels may provide hazard symbols (Table 2) or list the hazards associated with the chemical (e.g., flammable, oxidizer, poison, toxic, corrosive, or reactive).

Table 3 provides general information about the primary hazard classes and chemical incompatibility. Reference this chart when designing storage areas or determining segregation strategies. A detailed chemical segregation chart established by the EPA can be found on the EHS website. EHS is available to provide additional information and assistance with chemical segregation.

Chemical segregation can be accomplished using shelves, bins, cabinets, and other secondary containment equipment. Another way to reduce the potential for reactions between chemicals is to prevent contact by proximity. Storing solid oxidizing compounds on the opposite side of the laboratory from flammable liquids significantly reduces the possibility of contact. Acids and bases can be separated from one another by means of a divider or wall within a corrosive cabinet.

Table 2. Chemical Hazard Classes for Chemical Storage

Chemical Hazard Class	Incompatible Material	Hazard Symbols
Flammable Materials Materials with a flashpoint less than 60˚C (140˚F). Examples: hydrogen, hexane, xylene, ether, toluene, silanes, acetone, solvents, alcohols, and ketones.	Oxidizers, Acids, Bases, Toxic material, Reactive material	
Oxidizers Materials that readily release oxygen or oxidize surrounding compounds. Examples: nitrates, nitrites, peroxides, persulfates, perchloric acid, nitric acid red, chromic acid, and compressed oxygen.	Flammable materials, Bases, Acids, Reactive materials, Toxic materials	
Inorganic Acids Materials with a pH less than 2. Examples: hydrochloric acid, nitric acid, and phosphoric acid.	Bases, Organic acids, Oxidizers, Toxic materials, Reactive materials	
Organic Acids Materials with a pH less than 2. Examples: acetic acid, butyric acid, formic acid and trichloroacetic acid	Bases, Inorganic acids, Oxidizers, Toxic materials, Reactive materials	
Bases Materials with a pH higher than 12.5. Examples: sodium hydroxide, potassium hydroxide, amines, and ammonium hydroxide solutions.	Flammable materials, Acids, Oxidizers, Reactive materials	

Toxic materials Materials that are carcinogenic, teratogenic or pose and inhalation hazard. Examples: acrylamides, halogentated materials, ethidium bromide, phenol, chloroform, cyanides, and heavy metals.	Acids, Bases, Flammable materials, Oxidizers, Reactive materials	 
Reactive materials Materials that react with water/air or spontaneously combust on contact with other chemicals. Examples: metal hydrides, pyrophorics, water reactive material, borohydrides, borane complexes, anhydrides, calcium, sodium, and metal powders.	Acids, Bases, Flammable materials, Oxidizers	 

9.4 Compressed Gas and Cylinder Storage

Cylinders of compressed gas may pose both an inhalation hazard and physical hazard. The guidelines below should be followed to safely store compressed gas cylinders:

- Inspect newly-received cylinders to verify that the cylinder is labeled with the complete chemical name of the contents and the manufacturer, the cap is secure, and the cylinder is not leaking.
- If a cylinder is leaking, leave the area and contact EHS. Do not attempt to repair a cylinder or valve.
- Secure all cylinders to a wall, bench, or fixed support using a chain or strap placed 2/3 of the way up the length of the cylinder, or use a cylinder stand.
- Strap or secure cylinders independently from one another.
- Store cylinders indoors in secured locations. Cylinders may not be stored outside or in an unsecured area.
- Store full and empty cylinders separately.
- Label empty cylinders as “Empty”.
- Do not expose a cylinder to temperatures higher than 52°C (125°F) or to an open flame.
- Do not place cylinders where they may become part of an electric circuit.
- Keep the number of cylinders in a laboratory to a minimum.
- Return cylinders, including lecture bottles, to the distributor or manufacturer promptly once they are no longer needed. In the event that this is not possible, contact EHS.
- Do not store cylinders containing oxidizing gases, full or empty, within 50 feet of cylinders containing flammable gases, unless the storage areas are separated by a firewall with a minimum height of five feet and a fire rating of one hour.
- Do not store greasy or oily materials near cylinders containing oxygen or apply grease to the fittings of these cylinders.
- Never place an acetylene cylinder on its side.

9.5 Flammable Chemical Storage

Flammable liquids are liquids with a flashpoint less than 60°C (140°F). The guidelines below should be followed to safely store flammable chemicals.

- Store flammable chemicals in metal cabinets in accordance with the SFPC 3404.3.2.1.1.
- When refrigerating flammable chemicals, use a flammable materials storage refrigerator that meets Underwriters Laboratory, Inc. (UL) design requirements for special purpose refrigerators and freezers. These specialized refrigerators are designed so the unit does not contain any switches that could arc or generate a spark that acts as a source of ignition. This is accomplished by sealing the compressor chamber and locating the electrical components on the outside of the unit. The refrigerator must be clearly marked with the words, "NO FOOD OR DRINK-CHEMICAL STORAGE ONLY."
- Keep flammable storage areas away from electrical equipment, heat, oxidizing chemicals, and ignition sources.
- Store flammable chemicals in their original container or in a metal safety can.
- Do not keep more than three flammable storage cabinets in a laboratory, unless they are separated by 100 feet or more.
- Do not store more than 60 gallons of flammable chemicals in a single flammable cabinet.
- Do not store more than 10 gallons of flammable chemical outside of a flammable cabinet unless safety cans are used. If safety cans are used, 25 gallons of flammable chemicals may be stored outside of the flammable cabinet.
- Consider using a central storage area equipped to store flammable chemicals or contact EHS for assistance.

9.5.1 Reactive Chemical Storage

Reactive chemicals react violently with water, air, chemicals or spontaneously combust to produce toxic gases, heat, fire, or explosion. The following are storage guidelines for reactive chemicals.

9.5.2 Air- and Water-Reactive Chemical Storage

The guidelines below should be used to safely store air- and water-reactive chemicals:

- Review the manufacturer's storage requirements.
- Store reactive chemicals in the original manufacturer's container or chemically compatible containers equipped with tight sealing caps.
- Store reactive chemical containers inside an impermeable secondary container.
- Clearly marking each primary and secondary container with the words "Air Reactive" or "Water Reactive."
- Segregate water-reactive chemicals from all liquids.
- When storing water-reactive chemicals in a refrigerator, use caution to prevent condensation from reacting with the chemical. Condensation can collect on the container, be transferred to gloves, and inadvertently react with the compound once the container is opened.

- Store air-reactive chemicals under nitrogen or submerge the compound in a compatible nonreactive solution such as oil to prevent exposure to air.
- Inspect the container frequently for integrity. For assistance in discarding or repackaging the chemical contact EHS.
- If the physical state of the chemical is visibly altered or there is reason to suspect that a reaction has occurred within the container, do not attempt to move the container or stabilize its contents. Contact EHS to arrange for safe stabilization and disposal.

9.5.3 Peroxide-Forming Compound Storage

Peroxides are intrinsically unstable due to the weak oxygen-to-oxygen covalent bond from which their name derives. Peroxide-forming compounds immediately begin to produce these bonds with exposure to air. Over time, the concentration of peroxides may reach a dangerous level when improperly stored; exposure to excessive heat, light, friction, or impact, can initiate a chain reaction resulting in detonation. Crystal formation around the cap or inside of a bottle, and a cloudy appearance in the liquid are obvious signs that peroxides may be present. If a container appears to have any of these characteristics, do not handle or attempt to move the chemical. Secure and label the area as dangerous and contact EHS. The guidelines below should be used to safely store peroxide-forming compounds:

- Label the container with the date that it is received and placed in inventory.
- Purchase inhibited chemicals when possible.
- Keep caps tightly sealed when chemicals are not in use to avoid prolonged exposure to oxygen.
- Do not store peroxide-forming chemicals in glass bottles with ground glass stoppers.
- Store chemicals in a flammable materials storage refrigerator or cool area away from sunlight, heat, and oxidizing compounds. Do not store chemicals at temperatures at which they will freeze as this will precipitate the peroxides making them extremely shock sensitive.
- Do not store chemicals beyond their expiration date or storage limitations listed in Table 3.
- In the absence of an expiration date or listing in Table 3, assume a 12-month expiration date from the received date.
- Because of the explosive nature of expired peroxides, contact EHS if expired peroxide-forming chemicals are discovered and do not attempt to move them.

Table 3. Storage Limitations for Peroxide-Forming Chemicals

Expires in 3 Months	Expires in 12 Months	
• Isopropyl Ether	• Ethyl Ether	• Methylcyclopentane
• Divinyl Acetylene	• Tetrahydrofuran	• Acetal
• Vinylidene Chloride	• Diazine	• Styrene
• Sodium Amide	• Methyl Butyl Dimethyl Ether (Diglyme)	• Butadiene
• Potassium Amide		• Tetrafluoroethylene
• Potassium Metal	• Vinyl Ethers	• Chlorotrifluoroethylene
	• Dicyclopentadiene	• Vinyl Acetylene
	• Diacetylene	• Vinyl Acetate
	• Methyl Acetylene	• Vinyl Chloride
	• Cumene	• Vinyl Pyridine
	• Tetrahydronapthalene	• Chlorobutadiene (Chloroprene)
	• Cyclohexene	• Dioxanes

9.5.4 Temperature-Sensitive Chemical Storage

Improper storage of temperature-sensitive chemicals can result in a BLEVE that can violently rupture the container. Additionally, the product involved in a release may be reactive, flammable, or harmful to health thereby increasing the hazards and consequences to health and safety. The guidelines below should be used for safely storing temperature-sensitive chemicals:

- Clearly mark each container with the words "Temperature-Sensitive Chemical."
- Store chemicals, even those that are to be discarded, in a flammable materials storage refrigerator that meets UL design requirements for special purpose refrigerators and freezers. The refrigerator must be clearly marked with the words, "NO FOOD OR DRINK - CHEMICAL STORAGE ONLY." Routinely verify that flammable materials storage refrigerators are maintaining the proper storage temperature for the materials they contain.
- Ensure that the chemical is returned to a flammable materials storage refrigerator immediately after use.

9.5.5 Multi-nitrated Chemical Storage

Some multi-nitrated compounds decompose violently when subjected to shock, heat, or other chemicals. Most multi-nitrated compounds become more sensitive to shock and temperature when they become dry. The guidelines below should be used to safely store multi-nitrated compounds:

- Keep caps tightly sealed to prevent compounds from drying.
- Inspect containers of multi-nitrated compounds frequently to ensure that they have adequate moisture.
- If a dry multi-nitrated compound is discovered, contact EHS to arrange for disposal. Do not attempt to stabilize or move the container.

9.6 Oxidizing Chemical Storage

An oxidizing chemical is a chemical that will cause a substantial increase in the burning rate of a combustible material with which it comes in contact, undergo vigorous self-sustained decomposition when catalyzed or exposed to heat, or cause spontaneous ignition of combustible or flammable chemical with which it comes in contact. Strong oxidizing agents will react with solvents, wood, and fine metal powders. The guidelines below should be used for safely storing oxidizing chemicals:

- Clearly mark the storage area where oxidizing chemicals are stored with the words: "Oxidizers," "Oxidizing Chemicals," or a DOT hazard class placard for Oxidizing Materials (Table 1).
- Do not store oxidizing chemicals with acids, bases, reactive chemicals, or flammable chemicals.
- Do not store oxidizers near sources of heat including laboratory equipment and open flames.
- Do not store oxidizers on or within incompatible materials (e.g., wooden shelves and cardboard containers).

9.7 Organic Peroxide Storage

Organic peroxides are extremely flammable and many are more sensitive to detonation than primary explosives such as trinitrotoluene. Due to their sensitivity to shock, heat, and sparks special consideration should be given to storage of these compounds. The guidelines below should be used to safely store organic peroxides:

- Clearly label the container with the words "Organic Peroxide."
- Store organic peroxides at the lowest temperature possible above freezing, preferably in a flammable chemicals refrigerator that meets UL design requirements. The refrigerator must be clearly marked with the words, "NO FOOD OR DRINK - CHEMICAL STORAGE ONLY."
- If organic peroxide is stored in a refrigerator that also contains flammable chemicals, place the organic peroxide in a sealed secondary container with an organic peroxide label.
- Store organic peroxides away from light, heat, acids, and flammable chemicals.

9.8 Toxic Chemicals Storage

The guidelines below should be used to safely store toxic chemicals:

- Store Particularly Hazardous Substances in an adequately-ventilated designated storage area that clearly identifies the hazard present. The designated storage area must be near the designated work area.
- Clearly label all containers with the appropriate words: "Known Carcinogen," "Suspected Carcinogen," "Reproductive Toxin," or "Acutely Toxic."
- Clearly mark containers of poisons that pose an inhalation hazard with the words "Poison-Inhalation Hazard."

- Do not store Particularly Hazardous Substances with acids or bases.
- Ensure containers remain tightly sealed when not in use.
- Store the primary container inside of an unbreakable, sealable secondary container.

9.9 Corrosive Chemical Storage

Corrosive chemicals include acidic and basic chemicals. The guidelines below should be used to safely store corrosive chemicals:

- Do not store acids and bases together.
- Do not store acids with other chemicals.
- Segregate organic acids and inorganic acids from one another.
- Place chemically-compatible acids in a chemically-resistant plastic bin or other secondary containment to protect metal shelving, cabinetry, and contain spills.
- For hydrofluoric acid:
    - Never store hydrofluoric acid in a glass container.
    - Store hydrofluoric acid in an acid storage cabinet.
    - Store minimal amounts of hydrofluoric acid in the laboratory.

10.0 Laboratory Safety Procedures

The most important element of laboratory safety is adherence to good laboratory practices that reduce the risk of exposure to laboratory hazards. Laboratory personnel must be trained and proficient in the practices and techniques required for work in the laboratory. PI/LS are responsible for identifying and adopting practices and procedures designed to minimize or eliminate exposure to laboratory hazards and for training all laboratory personnel. The following general safety guidelines should be followed in all research and instructional laboratories:

- Before beginning work in the laboratory:
    - Complete required safety training and specific laboratory training.
    - Be familiar with the *Laboratory Safety Manual, Supplemental Laboratory Safety Plan*, the location and use of safety equipment, SDS, and laboratory-specific emergency procedures.
    - Receive appropriate medical evaluations, tests and vaccinations as outlined in the university's *Medical Surveillance Plan*.
    - Know the location of emergency equipment such as chemical spill supplies, emergency showers, eye wash stations, fire extinguishers, and additional laboratory-specific supplies.
    - Consult the SDS of the chemicals to be used in order to determine risks associated with the chemical, symptoms of exposure, first aid procedures, appropriate PPE, and recommended safety precautions.
    - Be familiar with spill response procedures for the substances being used.
- Restrict access in instructional and research laboratories to approved laboratory personnel or visitors who have received appropriate safety training.
- Keep the door to the laboratory closed at all times and locked when the laboratory is not in use.
- Avoid working alone in the laboratory.
- Provide warning signs to identify physical hazards [e.g., equipment that operates at extreme temperatures, exposed sharps and sharp edges (that cannot be altered/removed), or moving parts].
- Avoid using combustible, flammable, or reactive chemicals around ignition sources.
- Routinely inspect the laboratory for damaged or failing structures such as shelves, chemical storage units, and furniture.
- Implement good laboratory housekeeping practices and maintain a clean and tidy laboratory to prevent chemical accidents and injuries.
    - Clean work surfaces regularly.
    - Keep floors and access to safety equipment clean and unobstructed.
    - Do not store instruments, small equipment (e.g., vacuum pumps, tabletop centrifuges, ring stands) and chemicals on the floor.
- Conduct informal inspections to identify problem areas in the laboratory and notify EHS of any safety issues or concerns.
- Make certain the area selected to perform procedures is equipped with the appropriate safety equipment.

- Adhere to the facility-specific limits on chemical use outlined in the *Supplemental Laboratory Safety Plan*.
- Wear appropriate PPE.
- Confine long hair, loose clothing, and jewelry.
- Do not eat, drink, use tobacco products, apply cosmetics, or store food or beverages in the laboratory.
- Follow proper procedures for labeling and storing chemicals and make sure chemical storage containers are in good condition.
- Use a chemical fume hood whenever possible, particularly for operations that may release airborne particulate matter or chemical vapors.
- Line work surfaces with absorbent, flame-retardant, plastic-backed bench paper that can be discarded after use, or use chemically-resistant trays or pans that can be easily decontaminated.
- Use equipment only for its designated purpose.
- Handle glassware carefully. Shield glass apparatus that have the potential to implode or explode.
- Glassware that is chipped, cracked, or shows other signs of flaws should not be used and should be disposed of in a broken glass box.
- Minimize splash and aerosol production by:
    - Conducting procedures that may produce aerosols in a chemical fume hood (for chemical or radioactive material aerosols) or biosafety cabinet (for aerosols containing biological material);
    - Keeping tubes sealed during vortexing or centrifugation;
    - Allowing aerosols to settle before opening centrifuge, blender, or the tube;
    - Using mechanical pipetting devices to transfer chemicals; and
    - When combining liquids, discharging chemical down the side of the container or as close to the surface of the chemical as possible.
- Do not smell, taste, or touch chemicals to identify, manipulate, or transfer them.
- Never pipette by mouth.
- Avoid activities that might confuse, startle, or distract other laboratory personnel.
- Identify unattended experiments with proper signage and warnings, provide secondary containment for unattended experiments in case equipment fails or breaks, and leave the laboratory lights on. Experiments that require electrical devices should have controls that can automatically shut off the equipment at a determined time or cut power in the event of a spill or accident. Experiments that require open flames or have the potential to start a fire must not be left unattended.
- Handle unknown chemicals as hazardous chemicals until they are properly identified. Unknown chemicals must be stored in an appropriate container and labeled as "Unknown" until they have been identified. If an unknown chemical cannot be identified, contact EHS.
- Before heating a chemical, consider its physical and chemical properties. The boiling point and flashpoint of the chemical, as well as dangers associated with chemical vapors, should be considered.
- Avoid heating liquids in closed containers to prevent a BLEVE, which can occur when the vapor generated from heating a liquid has sufficient force to rupture the container.

- Exchange mercury thermometers for alcohol thermometers by contacting EHS.
- Decontaminate work surfaces, instruments, and equipment after each use and immediately after a spill according to recommended decontamination procedures. Contact EHS for more information regarding appropriate decontamination procedures.
- Follow hazardous waste disposal procedures outlined in this manual.
- Do not dispose of hazardous waste into sinks unless specific direction has been given by EHS.
- Wash hands after completing work and before leaving the laboratory.
- Leave lab coats and other PPE in the laboratory before exiting.
- Remain alert to unsafe conditions. Take steps to rectify unsafe situations and bring laboratory safety issues to the attention of EHS.

10.1 Additional Procedures for Using Compressed Gas and Cylinders

In addition to the laboratory safety guidelines listed above, the procedures below should be followed when working with compressed gas and cylinders:

- Do not handle or use a cylinder without receiving hands-on training from the PI/LS or other qualified individual.
- Follow storage recommendations for cylinders provided in this manual.
- Never roll or drag a cylinder. Always use a cylinder cart to move cylinders.
- Cylinder valves must be protected from physical damage by means of a protective cap, collar, or other similar device while in storage and during transport.
- Refer to the chemical SDS and follow manufacturer's directions when attaching distribution lines and regulators to a cylinder. Not all distribution lines are compatible with all types of compressed gas, and some regulators are not interchangeable among cylinders.
- Wear a face shield when connecting and disconnecting cylinder regulators and distribution lines.
- Ensure that gas distribution lines are accessible and as short as safety permits.
- Clearly label distribution lines and outlets with the product name.
- Use check valves to prevent flow reversal in cylinder distribution lines when necessary.
- Visually inspect distribution lines for leaks, cracks, holes, or kinks.
- Inspect cylinders regularly for leaks, corrosion, cuts, dents, and any other damage which may affect operation. If damage is observed, the cylinder must be taken out of operation and returned to the vendor.
- Check for leaks with an acceptable leak-detecting liquid, such as Snoop®. Never attempt to identify leaks with an open flame.
- Never remove the cylinder valve handle, or attempt to repair, refill, or alter the cylinder in any other way. Cylinder alterations and repairs may only be made by the manufacturer.
- When opening the valve on a cylinder, position the valve facing away from you and other personnel. Open the valve slowly and completely.
- Do not use wrenches, pliers, or other hand tools to open a cylinder. If a cylinder is unable to be opened by a hand, return the cylinder to the manufacturer.
- After each use, close the cylinder valve and bleed distribution lines.

- Never empty a cylinder to a pressure lower than 172 kPa (25 psi).
- When a cylinder is empty, close the valve, remove the regulator, replace the valve cap, and mark the cylinder as "Empty."
- If there is a possibility that a contents of a cylinder are contaminated, label the cylinder as possibly contaminated with the name of the contaminant.
- Return all compressed gas cylinders, including lecture-size cylinders, to the supplier when empty or no longer in use. Contact EHS for assistance in arranging cylinder returns and disposal if the supplier is unknown or an unlabeled cylinder is found.

10.2 Additional Procedures for Using Flammable Chemicals

In addition to the general safety guidelines listed above, the procedures below should be followed when working with flammable chemicals.

- Follow storage procedures for flammable chemicals provided in this manual.
- Before beginning any work with flammable chemicals, be prepared to respond to a fire. Know the location of the nearest fire extinguisher and manual fire alarm pull station, and be familiar with emergency procedures.
- Use flammable chemicals in a well-ventilated area free from ignition sources, including heat and open flames.
- Limit the amount of flammable chemical outside of the flammable chemicals storage area to the amount required for the experiment or procedure.

10.3 Additional Procedures for Using Reactive Chemicals

In addition to the laboratory safety guidelines listed above, the procedures below should be followed when working with reactive chemicals.

- Follow storage procedures for reactive chemicals provided in this manual.
- Limit the amount of reactive chemical outside of the storage area to the amount required for the experiment or procedure.
- Perform all work in a chemical fume hood.
- Do not use or dispense water-reactive chemicals near a sink, open containers of liquid, on a wet or damp surface, or in an area where the relative humidity exceeds 50%.
- Do not use metal instruments or allow metal oxides to come in contact with peroxide-forming chemicals.
- Keep temperature-sensitive chemical at the appropriate temperature at all times.
- Do not use peroxide-forming chemicals that have crystals formed on the cap of the container or have a cloudy appearance.

10.4 Additional Procedures for Using Oxidizing Chemicals

In addition to the general safety guidelines listed above, the procedures below should be followed when working with oxidizing chemicals:

- Follow storage procedures for oxidizing chemicals provided in this manual.

- Avoid mixing oxidizing chemicals with flammable chemicals. If reactions require mixing oxidizing chemicals with flammable chemicals, use diluted solutions and take precautions to prevent fires.
- Do not use oxidizing compounds near ignition sources.

10.5 Additional Procedures for Using Organic Peroxides and Peroxide-Forming Chemicals

In addition to the general safety guidelines listed above, the procedures below should be followed when working with organic peroxides and peroxide-forming chemicals:

- Follow storage procedures for organic peroxides and peroxide-forming chemicals outlined in this manual.
- Design experiments to require the least amount of chemical possible.
- Do not intentionally introduce foreign chemicals or contaminates to chemical containers because this may create an unstable compound. If this occurs contact EHS to arrange for stabilization or disposal.
- Do not return unused chemicals to the original container.
- Use only Teflon® or ceramic-dispensing tools. Metal tools may introduce metal contaminates that can accelerate peroxide formation.
- Periodically inspect chemical inventories for unused and expired chemicals.
- Contact EHS to arrange for the safe disposal.

10.6 Additional Procedures for Using Toxic Chemicals

In addition to the general safety guidelines listed above, the procedures below should be followed when working with toxic chemicals.

- Before beginning work with toxic chemicals, become familiar with the risk involved, the possible routes of exposure, and the primary symptoms of exposure by reviewing the SDS. Consult with EHS if necessary.
- Follow storage procedures outlined for storing toxic chemicals in this manual.
- Limit the amount of toxic chemical outside of the storage area to the amount required for the experiment or procedure.
- To reduce the risk of exposure, use disposable PPE that is discarded after each use.
- Conduct procedures that may generate aerosols or particulates in a chemical fume hood, glove box, or a Class II Biosafety Level 2 hard-ducted biological safety cabinet. If these engineering controls cannot accommodate the work, use a localized exhaust system.

10.6.1 Particularly Hazardous Substances

Follow these additional procedures for Particularly Hazardous Substances:

- Consult with EHS prior to purchasing or beginning work with these substances to establish proper work practices, procedures, and determine proper disposal considerations.
- Follow written procedures for these substances that include location of designated areas for using and storing the substances, decontamination procedures and waste handling procedures. These procedures should be established by the PI in the *Supplemental Laboratory Safety Plan*.
- Establish a designated work area and a designated storage area for these substances. The designated work area must be clearly labeled, as shown in Figure 6.
- Access should be restricted to personnel knowledgeable of the hazards associated with the work performed.
- Do not allow normal laboratory work to resume in a space that has been used as a designated area until the area has been properly decontaminated in accordance with the method established by the PI in the *Supplemental Laboratory Safety Plan*. Make sure all containers are labeled with the chemical name and the appropriate hazard warning (e.g., "KNOWN CARCINOGEN," "SUSPECTED CARCINOGEN," "REPRODUCTIVE TOXIN," or "ACUTELY TOXIC").
- Handle materials (e.g., containers, used decontamination and spill supplies, and PPE) contaminated with acutely toxic chemicals as hazardous waste.
- Always use a chemical fume hood with a face velocity between 80 fpm and 120 fpm or other means of local exhaust and wear all appropriate PPE when working with these chemicals.
- For acutely toxic chemicals:
    - Never work alone.
    - Maintain records of the amounts of these chemicals stored, used, and the names of the personnel involved.
    - Never attempt to clean a spill. Evacuate the area and contact EHS.

Figure 5. Designated Work Area Signage

10.6.2 Chemicals with High Chronic Toxicity

Follow these additional procedures for work involving chemicals of high chronic toxicity:

- Before beginning work with chemicals of high chronic toxicity, contact EHS to seek medical consultation.
- Designate a specific work area that is to be used for work with high chronic toxicity and label this work area.

- Maintain records of the amounts of these chemicals stored, amounts used, dates of use, and the names of users.
- Never attempt to clean a spill. Evacuate the area and contact EHS.
- When cleaning and decontaminating the designated area, do not dry sweep powdered chemical.
- Upon leaving the designated area, remove PPE and thoroughly wash hands, forearms, face, and neck.
- Decontaminate vacuum pumps and other contaminated equipment, including glassware in the chemical fume hood before removing them from the designated area.

10.7 Additional Procedures for Using Corrosive Chemicals

In addition to the laboratory safety guidelines listed above, the procedures below should be followed when working with corrosive chemicals:

- Follow storage procedures outlined for storing corrosive chemicals in this manual.
- Transport using secondary containment and perform work in a chemical fume hood (except for perchloric acid).
- Perchloric acid is highly reactive and requires specialized equipment to work with safely, such as a perchloric acid fume hood to prevent the formation of concentrated perchlorate crystals which can be explosive. For this reason, perchloric acid should not be used in a laboratory prior to the purchase and installation of such a device.
- If your work requires work with perchloric acid, contact EHS.
- When diluting concentrated corrosives always add them to water in small amounts to limit the exothermic reaction; adding water to a concentrated corrosive will heat the water to boiling and cause splatter or an explosion.
- For work with hydrofluoric acid:
    - Obtain prior approval from the PI/LS before beginning work with hydrofluoric acid.
    - Develop written SOP for using, storing, and disposing of hydrofluoric acid.
    - Have a sufficient quantity of calcium gluconate (in gel form) on hand in the laboratory in the event of an exposure. If direct contact with hydrofluoric acid is suspected, remove contaminated clothing immediately and apply calcium gluconate to the affected area.
    - Never store hydrofluoric acid in a glass container.
    - Store hydrofluoric acid separately in an acid storage cabinet and keep only the amount that is necessary in the laboratory.

10.8 Additional Procedures for Chemicals Produced in the Laboratory

In addition to the laboratory safety guidelines listed above, the procedures below should be followed when working with chemicals produced in the laboratory:

- PI/LS must determine if the chemical is hazardous.
- If the chemical is hazardous, the PI/LS must provide training to laboratory personnel specific to the hazards presented by the chemical.

- If the chemical is produced is a by-product with an unknown composition, the PI/LS must assume that the chemical is a hazardous chemical and shall implement appropriate safety procedures.
- If the chemical is sold or distributed to a user outside the laboratory, the PI/LS may be required to comply with the Toxic Substances Control Act. Contact EHS for more information on these requirements.

10.9 Additional Procedures for Cryogenic Liquids and Dry Ice

In addition to the laboratory safety guidelines listed above, the procedures below should be followed when working with cryogenic liquids and dry ice:

- Wear insulated gloves that are thick enough to provide protection against burns and loose enough to be removed easily with one hand in the event that the cryogenic liquid becomes trapped close to the skin.
- Wear goggles and a face shield when transferring cryogenic liquids.
- Do not store dry ice in sealed containers. As dry ice sublimates, it can generate tremendous pressure and rupture sealed containers.
- Never release cryogenic liquids or dry ice into a laboratory sink as they may cause pipes to rupture.
- Never allow dry ice to sublimate or cryogenic liquids to boil off even at small amounts in a laboratory as this will displace oxygen and create an asphyxiation hazard. Never seal containers without proper venting or pressure relief of cryogenic liquids as this will cause an unsafe buildup of pressure which may result in a BLEVE.

10.10 Additional Procedures for Chemical Decontamination

After an area has been used for chemical manipulations or is used as a designated area for particularly hazardous substances, it must be decontaminated before it may be used for other purposes. Decontamination methods involve either physically removing contaminants, inactivating chemical contaminants by chemical neutralization or by removing contaminants through a combination of both physical and chemical means. The selection of an appropriate decontamination method will vary and will depend upon the following:

- Physical, chemical and toxicological properties of the chemical used;
- Type of chemical or surface that is contaminated; and
- Location, extent, and amount of contamination.

Follow these guidelines when decontaminating surfaces or equipment:

- Consult the SDS regarding the physical, chemical, and toxicological properties and hazards of the chemical and for specific decontamination procedures.
- Wear appropriate PPE. At a minimum, safety glasses, gloves, and a lab coat must be worn.
- If a contaminant is reactive, stabilize the chemical, if possible, prior to decontamination.

- With the exception of areas contaminated with water reactive chemicals, most contaminated areas can be cleaned using soap and water. In place of soap and water, a 10-20% solution of ethanol may be suitable if compatible.
- When inactivating biological toxins, a solution of 0.25% sodium hypochlorite should be used with a minimum contact time of thirty minutes. Some toxins will require the addition of 0.25 normal solution of sodium hydroxide as well.
- For solid chemicals or water-reactive chemicals, if safe to do so, use dry diatomaceous earth, sand, or similar noncombustible material to encapsulate materials and dry sweep or shovel the material into a dry container before completing decontamination with a High Efficiency Particulate Air (HEPA) vacuum.
- Work from the outside of the contaminated area, cleaning inward using a series of concentric circles.
- Decontaminate all tools, equipment, and surfaces that come in contact with the contaminant before they are reused, repaired, or discarded.
- Decontaminate laboratory equipment according to the procedures provided above. If this equipment is to be removed from the laboratory (e.g., repair, laboratory relocation, surplus, or disposal), certifying documentation that the equipment was properly decontaminated must accompany the equipment. *Decontamination Certificates* are available on the EHS website.
- Collect all contaminated materials (PPE, absorbent chemical, and debris) in a sealed container or bag for disposal as hazardous waste.

Contact EHS to request assistance or guidance with decontamination projects.

10.11 Additional Procedures for Using Sharps

To lessen the risk of accidental infection, the use of sharps should be avoided when alternate methods are available. Sharps are laboratory instruments or equipment capable of causing a puncture or cut including needles, scalpels, razor blades, glass Pasteur pipettes, slides, and broken glassware.

Sharps should be stored in a manner that prevents injury and should never be left unattended in a manner that could result in an accidental injury. Personnel should be familiar with proper storage, use, and disposal of sharps. For animal handlers, injury could occur when restraining an animal during a procedure involving the use of needles.

The following precautions should be observed when working with sharps:

- Always use safe needle devices (e.g., self-sheathing needle, retractable needle) unless it's not feasible for the work being conducted.
- Use disposable needles and safety needle-locking syringes. Replace glass syringes with plastic disposable syringes whenever possible.
- Never reuse needles that may be contaminated with infectious material.
- Dispose of the entire unit (syringe and safety needle) into a sharps container.
- Do not bend, shear, recap, or otherwise manipulate the needle.

- Be sure that the safety needle is locked securely into the barrel before performing any operations.
- Avoid quick and unnecessary movements while holding the sharps.
- Do not use the syringe to forcefully expel a stream of hazardous fluid into an open vial for the purpose of mixing.

Sharps must be disposed of in approved sharps containers and must not be disposed of in municipal waste. Sharps contaminated with Particularly Hazardous Substances must be handled as hazardous waste. he *Biological Safety Manual* provides detailed safety guidelines for the safe use of needles and syringes with biohazardous material and animals.

10.12 Constructing a Chemical Apparatus

When setting up a laboratory apparatus:

- Keep work surfaces clean and uncluttered.
- Firmly clamp the apparatus to a sturdy support and set it up as far from edge of the lab bench as possible.
- Only use equipment that is free from cracks, chips, or other defects.
- If possible, place a pan under a reaction vessel or other container to contain liquid if the glassware breaks.
- Do not allow burners or any other ignition sources nearby when working with flammable liquids.
- Lubricate glass stopcocks.
- Properly support and secure condensers and water hoses with clamps and wires. Be sure to direct the water hoses so that any drips that may come from the hoses do not splash onto any electrical wires or devices.
- Position an apparatus that is attached to a ring stand with the apparatus' center of gravity over the base.
- Assemble the apparatus so that burners or baths can be removed quickly in an emergency.
- Use an appropriate vapor trap and confine the setup to a chemical fume hood if there is a possibility of hazardous vapors evolving.

10.13 Additional Procedures for Laboratory Equipment

PI/LS are responsible for maintaining laboratory equipment and providing training to laboratory personnel on the correct use of equipment. A routine inspection and maintenance program that includes necessary instrument calibration, certification, and maintenance procedures should be implemented for all equipment in the laboratory to identify worn parts, frayed wires, malfunctioning instruments, faulty safe guards, and other potential hazards. Follow these equipment safety guidelines:

- Do not allow personnel to use laboratory equipment without proper training.
- Use equipment only for its intended purpose. Do not modify or adapt equipment without guidance from the equipment manufacturer or EHS.

- Use applicable safeguards when operating equipment. Do not defeat, remove, or override equipment safety devices.
- Inspect equipment prior to each use to identify potential safety concerns.
- Perform preventative maintenance and maintain instrument calibration and certification as indicated by the manufacturer.
- Make sure that equipment maintenance is performed by a qualified individual.
- Properly decontaminate equipment before its removal from the laboratory (e.g., repair, laboratory relocation, surplus, or disposal). A *Decontamination Certificate* certifying that the equipment was properly decontaminated must accompany the equipment. If you feel you cannot properly decontaminate equipment, contact EHS for further assistance.
- Verify that equipment does not contain hazardous substances such as freon (refrigerators and cooling systems), lead (lead acid batteries), or mercury (mercury switches) before transport, removal, or disposal. EHS is available to assist PI/LS in certifying equipment is safe for removal from the laboratory.
- Place a work order with Facilities Management to move, surplus, or discard laboratory equipment.
- Check electrical cords for frayed or exposed wire.
- Use and maintain appropriate guards on exposed mechanical devices such as belt-driven vacuum pumps and moving parts on equipment.

10.14 Additional Procedures for Bunsen Burners and Open Flames

The misuse of Bunsen burners is a common cause of laboratory fires. Follow these procedures when using a Bunsen burner or other source of open flame:

- Ensure that the burner is in good condition and that the control valves work properly.
- Inspect gas supply hoses for cracks or holes and securely attach the hose to the gas valve stem.
- Place the Bunsen burner on a sturdy level surface away from overhead shelving, equipment, or light fixtures.
- Ensure that all unnecessary flammables, oxidizers, or temperature-sensitive chemicals and materials are removed from the work area (at least two feet from the burner).
- Once the gas has been turned on, immediately light the burner utilizing a sparker or lighter with an extended nozzle. Never use a match to ignite a burner.
- Regulate the flame to an appropriate level. Flames should not extend beyond the bottom edge of the surface being heated.
- Never leave an open flame unattended.
- If a Bunsen burner goes out unexpectedly, turn off the gas, inspect the hose connection and the burner, and begin the lighting process again. If the burner fails to light, turn off the gas and check the gas source and/or replace the burner.
- When the burner is no longer needed, turn off gas supply to the burner and remove the hose from the valve.
- In laboratories where open flames are used, a fire extinguisher must be available and laboratory personnel should know its location.
- *Fire Extinguisher Use* training is available through EHS.

10.15 Additional Procedures for Pressurized Systems

A system that increases or decreases ambient pressure inside of a vessel presents a pressure hazard (e.g., implosion, explosion). The guidelines below should be followed when using a pressurized system.

- All work at high pressure must be conducted in vessels designed, constructed, and tested for this purpose; all such vessels must be equipped with appropriate pressure relief and any other necessary control devices.
- Vessels used for high pressure work must be inspected prior to use for any visible signs of damage; and removed from service, or repaired by a qualified technician if any damage is found.
- Hydrostatically test periodically, based on use, for integrity.
- Conduct all vacuum operations behind a shield or in a chemical fume hood, and wear appropriate PPE (glasses, goggles, or face shield).
- Ensure proper strain relief for all hoses and connections.
- Vent all vacuum exhaust into a chemical fume hood.
- Use glassware specifically designed for vacuum operations (e.g., Erlenmeyer filtration flask).
- Inspect vacuum glassware before and after each use. Discard any glass that is chipped, scratched, broken, or otherwise stressed.
- Wrap all glassware exposed to vacuum in friction tape, loose cloth, or metal screen to contain the glass in the event of implosion.
- Ensure proper belt guards are in place on pumps before operation.
- Always use traps, scrubbers, and/or filters on vacuum lines to prevent chemicals from being drawn into the pump, building vacuum line, or water drain.
- Avoid using mechanical pumps for large volume distillation or concentration of volatile chemicals; use a water or steam aspirator instead.
- Replace and properly discard vacuum pump oil that is contaminated with condensate.
- Place secondary containment under equipment.
- Do not place a pump in an enclosed or unventilated area.

10.16 Electrical Safety

The major hazards associated with electricity are electrical shock and fire. Sparks from electrical equipment can serve as an ignition source for flammable or explosive vapors. The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current, the length of time of the exposure, and whether the skin is wet or dry. The following practices may reduce risk of injury when working with electrical equipment:

- Only use extension cords temporarily.
- If temporary wiring is required longer than eight hours, it must be disconnected before leaving the work area at the end of the work day.
- Extension cords must be UL or Factory Mutual approved, grounded (three-prong), and heavy duty in type.

- Replace electrical cords that have frayed or exposed wires. Qualified personnel should perform the replacement.
- Avoid contact with energized electrical circuits.
- Disconnect the power source and ensure that any capacitors are discharged before servicing or repairing electrical equipment.
- Minimize the use of electrical equipment in cold rooms or other areas where condensation is likely to occur. If this equipment must be placed in such areas, mount the equipment to the wall or vertical panel which can reduce but won't eliminate the effects of condensation.
- If water or a chemical is spilled onto or around equipment, and it is safe to do so, shut off power at the main switch or circuit breaker and unplug the equipment before responding to the spill.
- Only equipment with grounded (three-prong) plugs should be used. The third prong provides a path to ground that helps prevent the buildup of voltages that may result in an electrical shock or spark.
- Live parts of electric equipment operating at 50 volts or more (e.g., electrophoresis devices) must be guarded against accidental contact.
- Use circuit-protection devices that are designed to automatically limit or shut off the flow of electricity in the event of a ground fault, overload, or short circuit in the wiring system.
- Determine if laboratory outlets provide adequate amperage and appropriate voltage for the electrical requirements of all equipment used. Certain pieces of equipment may require other than standard 120 volt outlets.

For assistance with electrical requirements, contact Facilities Management.

10.17 Motor Safety

In areas where volatile flammable chemicals are used, motor-driven electrical equipment should be intrinsically safe or equipped with nonsparking induction motors or air motors. Avoid series-wound motors, such as those generally found in vacuum pumps, rotary evaporators, stirrers, and household appliances (e.g., blenders, mixers, power drills). If it is necessary to use motorized equipment, take precautions to reduce flammable vapors. Motors also pose the additional hazard of moving parts that can cause injury if they are exposed or unguarded.

11.0 Shipping and Transport of Chemicals

Shipping and transporting hazardous materials (chemicals, dry ice, biohazardous and radioactive materials) is strictly regulated. DOT regulates how these materials should be handled in domestic transport. The International Air Transport Association publishes regulations for how these materials must be packaged and shipped by air. Violating shipping and transport regulations, both knowingly or unknowingly, can result in significant financial penalties and potentially harm public safety or the environment. The following sections outline procedures that must be followed when transporting or shipping chemicals. See the *Biological Safety Manual* and *Radiation Protection Plan* for guidelines on shipping and transport of biological materials and radioactive materials, respectively.

11.1 Intracampus Chemical Transportation

When transporting hazardous chemicals between laboratories or buildings, precautions must be taken to prevent spills or accidental exposure. The guidelines below should be followed when transporting chemicals on campus.

- Ensure all containers are properly labeled and securely sealed.
- Use secondary containment to contain spills.
- Transport chemicals using a sturdy wheeled cart with a 2-inch rim.
- When transporting incompatible chemicals, separate secondary containment should be provided for each chemical.
- Secure cylinders to a cylinder cart before transport.
- Use a freight or cargo elevator to transport chemicals between floors.
- Do not leave the cart unattended at any time during transport.
- Contact EHS for transport of a large number or large quantity of chemicals. EHS must be consulted for all laboratory moves that involve the relocation of chemicals from one laboratory to another.

PPE should be worn to transport materials between laboratories in the same building. PPE worn for this purpose should be clean to prevent contamination of communal areas. Only one hand should be gloved so that one hand is free to touch communal surfaces (e.g., door handles, elevator buttons). Materials transported between buildings should be packaged in such a manner to prevent or contain spills during transport. Laboratory personnel may wear clean PPE during transport between buildings in the event of a spill.

11.2 Intercampus Transportation of Chemicals

Personnel may not transport chemicals off George Mason University property in personal vehicles. If research or instructional activities span multiple campuses, the necessary chemical supply should be maintained at each campus. In the event that a laboratory or operation is being relocated to an alternate campus or to a site off campus, EHS must be contacted as soon as possible, but at least two weeks in advance, to schedule a laboratory move with an approved, licensed vendor.

Personnel conducting field research may be permitted to transport limited quantities of hazardous material under the provisions of the DOT Materials of Trade exemption. Contact EHS for more information about this exemption.

11.3 Shipping Chemicals

Certification in hazardous materials shipping is required by DOT in order to ship hazardous materials. EHS is the only department at George Mason University authorized to ship hazardous materials and all shipments of chemical shipments must be handled by EHS. When scheduling a chemical shipment with EHS, laboratory personnel should contact EHS at least two days prior to the desired ship date and provide the following:

- Itemized list of contents of the package to include volume, weight, and size of the container(s);
- An appropriate shipping container that meets UN packaging requirements (Containers can be purchased through EHS if the department does not have the appropriate containers and the shipment is urgent.);
- Dry ice and quantity to be included in the package (if required);
- Package (length, width, height, and weight);
- Insurance for the package (if any); and
- Payment information.

Some laboratories may receive training and approval from EHS to ship biological materials and dry ice independently from EHS. Packaging and shipping must be conducted in accordance with DOT and ICAO regulations as outlined in this training. An MTA may be required when transferring materials to another institution or Investigator. More information on MTA is available from OSP. In addition, depending on the material to be shipped and the shipping destination, a United States Export Permit or an Import Permit from the country that is to receive the package may be required. PI/LS are responsible for understanding international permitting regulations pertaining to their work.

Additional information on shipping or transporting infectious materials is provided in the *Biological Safety Manual*.

12.0 Chemical Waste Management

Hazardous waste is defined by the EPA as any waste material that is ignitable, corrosive, reactive, or toxic, and that "may pose a substantial or potential hazard to human health and safety and to the environment when improperly managed." This includes hazardous chemicals, biological materials, and radioactive materials. EHS oversees the management of hazardous waste generated in George Mason University laboratories and incurs all routine costs associated with hazardous waste accumulation and disposal. This section of the *Laboratory Safety Manual* outlines procedures for managing laboratory waste with the exclusion of biological waste and radioactive waste which are discussed in the *Biological Safety Manual* and *Radiation Protection Plan*, respectively.

To comply with EPA regulations, laboratory personnel must manage all chemical waste as hazardous waste according to the procedures outlined below. PI/LS are ultimately responsible for the management of hazardous waste in the laboratories for which they are responsible, and must implement all relevant waste handling procedures provided in this section. Training in chemical waste management is provided in *Laboratory Safety Orientation*. Personnel who have not received this training are not authorized to handle chemical waste.

12.1 Waste Container Selection

Containers used to collect waste must be in good condition (i.e., free of cracks, punctures, or other defects), have tightly sealing lids, be designed for the type of chemical waste generated (e.g., containers are rated to hold a specific volume and weight), and compatible with the type of waste. An empty chemical container or waste containers provided by EHS may be used to collect waste. If an empty chemical container is used for waste collection, the original label must be completely removed or defaced and the container must be relabeled with a hazardous waste label.

12.2 Waste Container Labeling

All chemical waste containers must have a hazardous waste label that specifies the complete chemical name and percent by volume of each constituent. Hazardous waste labels are provided by EHS and can be printed from the EHS website. When the waste container is full, no longer needed, or a chemical is removed from storage as waste, the date should be recorded as the accumulation date on the hazardous waste label and the container should be moved to the satellite accumulation area.

If chemical waste contains biohazardous or radioactive material, an additional label that contains the appropriate symbol (universal biohazard symbol or radiation symbol, Figures 3 and 4) must be attached to the container and the biohazardous or radioactive constituents must be itemized. Information on how to use, manage, and dispose of radioactive materials is found in the university's *Radiation Protection Plan*.

12.3 Satellite Accumulation Areas

Satellite accumulation areas are designated areas within the laboratory where hazardous waste is accumulated, stored, and prepared for disposal. Each laboratory that generates hazardous waste must have a satellite accumulation area. PI/LS are responsible for managing the satellite accumulation area and for training laboratory personnel on its use. EHS provides each laboratory with materials and resources to establish and manage a satellite accumulation area, routinely inspects these areas to monitor compliance with waste regulations, and assists laboratory personnel with waste management and safety issues.

The satellite accumulation area must be located in an area that is mutually acceptable to EHS and PI/LS. EHS should be notified if the satellite accumulation area is relocated. Satellite accumulation areas can be placed on bench tops, inside a chemical storage cabinet, or in laboratory support rooms. Satellite accumulation areas that are not in plain view must be identified by signage.

All waste in the satellite accumulation area must be properly labeled, stored in secondary containment, and segregated according to chemical compatibility. If wastes in the satellite accumulation area are not properly labeled (e.g., the chemical name is abbreviated or there is no accumulation date), EHS cannot pick up the waste for disposal. A maximum of 55 gallons of non-P-listed waste or one quart of P-listed waste may be accumulated in a satellite accumulation area. If either of these conditions exists, contact EHS immediately to arrange a pickup, as the EPA requires this volume of waste be removed from the laboratory within three days.

Laboratory personnel should frequently inspect the satellite accumulation area for:

- Container integrity (e.g., leaks, cracks, open tops);
- Proper hazardous waste labels (i.e., complete chemical name, accumulation date, building, and room number);
- Proper chemical segregation; the presence of one or more incompatible materials requires secondary containment or an additional satellite accumulation area;
- Over-crowding; and
- Volume restrictions of 55 gallons of non-P-listed waste or one quart of P-listed waste.

12.4 Procedures for Handling Chemical Waste

The following procedures should be used for all chemical waste:

- Never dispose of hazardous waste in the laboratory sink unless authorized to do so by EHS.
- Select an appropriate container for the waste and affix a hazardous waste label with the name of the chemical(s) being accumulated to the container. Do not fill out the date until the container is ready to be collected.
- For liquid waste, use a funnel or spigot to transfer the waste into the container and use secondary containment to catch spills.

- Keep containers closed unless adding waste to the container. Open systems should be provided with a sealed waste container.
- Do not fill waste containers to greater than 90% capacity.
- Once the waste container is determined to be full, write the accumulation date on the label and place the container in the satellite accumulation area or other appropriate storage area (e.g., freezer) using appropriate secondary containment, segregation, and shielding.

12.5 P-listed Waste Disposal

EPA 40 CFR 261.33 requires strict management of hazardous waste containing acutely toxic chemicals (as listed in the EPA "P" waste code and identified as "P-listed waste"). Therefore, laboratory personnel must be able to identify P-listed waste and manage this waste properly. A list of chemicals that are considered P-listed waste according to the EPA is available on the EHS website.

Solid waste (e.g., gloves, disposable pipettes, tubes, and flasks, paper products, and empty containers) contaminated with acutely toxic chemicals or P-listed wastes must not be placed in municipal waste. This waste must be placed in a polyethylene bag or appropriate waste disposal container, labeled with a hazardous waste label, and placed in the satellite accumulation area for disposal.

12.5.1 Reactive Chemical Disposal

Reactive chemicals that are unstable, including potentially-explosive chemicals (e.g., peroxide-forming compounds, organic peroxides, etc.), require special handling prior to disposal. These chemicals may require the services of a trained professional to open and stabilize the chemical using special equipment. Do not make any attempt to move, transport, or stabilize the chemical. Prevent other laboratory users from using the chemical, restrict access to the area, and contact EHS to arrange disposal of these chemicals.

12.5.2 Chemical/Biological or Chemical/Radioactive Waste Disposal

Chemical waste containing biohazardous material must be labeled with a hazardous waste label, a label that contains the universal biohazard symbol, and a list of biohazardous constituents. When the container is considered full, the waste should be transferred to the satellite accumulation area or other appropriate storage location. If extra precautions or storage requirements are required when working with the biological agent contained within the waste stream, notify EHS to arrange a pickup immediately.

Chemical waste containing radioactive material (i.e., mixed waste) must be labeled with both a hazardous waste label and a label that contains the universal radiation symbol. The radioisotopes contained in the waste and total activity of the waste must be listed on the label. This waste will be handled as mixed waste, in accordance with procedures outlined in the *Radiation Protection Plan*.

12.5.3 Cylinder Disposal

All cylinders must be considered hazardous unless the valve has been removed. Return cylinders, including lecture bottles, to the distributor or manufacturer promptly once they are empty or no longer needed. In the event that this is not possible, contact EHS.

12.6 Procedures for Handling Other Laboratory Waste

The following procedures are recommended for disposal of laboratory waste in the sink or municipal waste.

12.6.1 Sink and Municipal Waste

In limited circumstances, it is appropriate to dispose of substances in a laboratory sink or municipal waste. Chemicals may not be disposed of in the sink or municipal waste unless specific guidance and approval from EHS is received.

- Used PPE, paper trash, and other forms of dry laboratory trash that are not contaminated with biological materials, radioactive materials, or acutely toxic chemicals, may be discarded as municipal waste.
- Empty containers, with the exception of containers for acutely toxic chemicals or P-listed waste which must be treated as hazardous waste, may be disposed of in the municipal waste or broken glass boxes, so long as they meet the following requirements.
    - All containers must be completely empty - no free liquid or residue may remain in the container.
    - The container must be completely rinsed at least one time.
    - Rinsate may be disposed of in laboratory sinks only. Empty rinsed containers must be completely defaced, removed, or otherwise made illegible before being placed into a broken glass box for disposal. Empty containers should not be disposed of in recycling bins.

12.6.2 Laboratory Glassware Disposal

Broken glass boxes are available from EHS and should be used only to accumulate unwanted, defective, or broken glassware. It is inappropriate to use these containers for anything other than glass waste that meets the criteria in this section. Once the broken glass box is approximately 75% full, tape the seams so that the lid is secure. These boxes should be disposed of in George Mason University dumpsters.

12.7 Hazardous Waste Reduction

DEQ and EPA regulations mandate that George Mason University implement waste reduction strategies whenever feasible. The following methods should be used to reduce the volume of hazardous chemicals in the laboratory to improve safety conditions and to minimize the amount of hazardous waste generated.

- Chemicals should be purchased in the smallest quantities needed for immediate use. This reduces storage space, potential for chemical accidents, and the cost of disposal. Disposal costs can easily offset any savings incurred from purchasing larger quantities.
- Whenever possible, hazardous chemicals should be replaced with less hazardous substitutes to reduce the amount and toxicity of waste.
- Donations and samples of chemicals from other academic institutions, research facilities, and businesses should not be accepted unless an immediate use is planned and the chemicals are suitable for use (e.g., not expired, unstable, or explosive).
- When PI/LS leave or relocate a laboratory at George Mason University, all chemicals under their control must be inventoried and transferred to the PI/LS's new laboratory, made available to other George Mason University laboratories, or disposed of.
- Experiments should be designed to render waste less hazardous or nonhazardous.
- Microscale techniques should be employed whenever possible to reduce the quantity of hazardous waste generated.

13.0 Laboratory Closeout or Renovation

Whether leaving and moving to a different institution, or relocating or renovating a laboratory within George Mason University, PI/LS are responsible for following proper closeout procedures. These procedures address material packaging and transfer, waste disposal, and laboratory and equipment decontamination.

13.1 Laboratory Closeout Procedures When Leaving George Mason University

When leaving George Mason University, it is important that PI/LS return the laboratory to a condition that will be immediately usable to the university. Material and equipment must either be transferred to a new institution or be properly decontaminated for reuse. In addition, waste must be handled appropriately before final departure. PI/LS are responsible for the following when leaving George Mason University.

- Notify EHS 30 days prior to your confirmed move date, but no later than two weeks (14 days) in advance.
- Provide EHS with the following information within 14 days prior to leaving:
    - An itemized list of hazardous substances and equipment to be relocated;
    - The method of relocation (e.g., commercial mover, commercial shipping company, etc.);
    - An itemized list of equipment and instruments that will remain at the university; and
    - An itemized list of materials and equipment that will be transferred to another George Mason University PI/LS and the name(s) of the PI/LS who will assume responsibility for these items.
- Prepare laboratory waste for disposal within the satellite accumulation area and schedule waste pickup with EHS.
- Decontaminate and label equipment or instruments that will remain at the university with a *Decontamination Certificate* prior to departure.
- Provide EHS with the Safety Records and Resources binder including the *Laboratory Training Signature Page* and other research-related documentation (e.g., material/reagent transfer or purchase agreements, equipment decontamination certifications, etc.).
- Contact OSP to prepare an MTA as necessary.
- Contact EHS to request personal exposure records.
- Remove all material, equipment, personal items, and reference materials from the laboratory that do not belong to George Mason University.

13.2 Laboratory Closeout Procedures When Switching Laboratories While at George Mason University

When moving to a new space or switching laboratories within George Mason University, it is important that PI/LS return their previous laboratory to a condition that will be immediately usable to the university. Material and equipment must either be properly disposed of or decontaminated and relocated to the new space. In addition, waste must be handled appropriately. PI/LS are responsible for the following when leaving George Mason University:

- Notify EHS 30 days prior to your confirmed move date, but no later than two weeks (14 days) in advance.
- Provide EHS with the following information within 14 days prior to your move date:
    - An itemized list of equipment and hazardous substances to be relocated;
    - Method of relocation (e.g., commercial mover coordinated by the Office of Space Management, department personnel, etc.) for both equipment and hazardous substances. Note that the transfer of hazardous substances between campuses is highly regulated by the DOT and must be conducted by a licensed contractor;
    - An itemized list of material and equipment that will remain in the laboratory and therefore will be transferred to another George Mason University PI/LS, and the name(s) of the PI/LS who will assume responsibility for these items; and
    - An itemized list of materials and substances that may require temporary storage (less than 30 days).
- Prepare laboratory waste for disposal within the satellite accumulation area and schedule waste pickup with EHS.
- Decontaminate and label equipment or instruments that will remain at the university with a *Decontamination Certificate* prior to departure.
- Relocate the Safety Records and Resources binder, SDS Library, and safety manuals to wall bins located in the new space as part of the move process. EHS will replace these items as necessary in the space being vacated. If desired, contact EHS for new binders for binder contents (i.e., SDS, training records, etc.) that will move with the lab to the new space.
- Remove all material, equipment, personal items, and reference materials from the laboratory.

13.3 Laboratory Renovation Procedures

EHS must approve renovations of existing laboratory spaces and alteration of a work space to or from a laboratory. Please observe the following procedures for laboratory renovation projects:

- Notify EHS as soon as possible but at least 30 days in advance.
- Consult with EHS regarding laboratory design.
- Provide EHS an itemized list of hazardous substances that will require temporary storage during the laboratory renovation project.
- Provide EHS an itemized list of hazardous substances and equipment that are proposed to be housed in the laboratory during renovation.
- Prepare laboratory waste for disposal and schedule waste pickup with EHS prior to commencement of renovation activities.
- Decontaminate and label equipment or instruments that will remain at the university with a *Decontamination Certificate* prior to the commencement of renovation activities.
- Decontaminate surfaces prior to the commencement of renovation activities.

14.0 Laboratory Emergencies

Emergencies, by their nature, are unpredictable and unexpected events that pose a potential threat to health and safety of personnel, property, and the environment. Laboratory personnel should be prepared to respond to emergencies such as spills of a hazardous substance, personal exposures, injuries, fire, or equipment failures. OSHA defines a chemical emergency as "equipment failure, rupture of containers or failure of control equipment that results in an uncontrolled release of a hazardous chemical into the workplace." Examples include:

- An accidental and uncontrollable spill from a broken bottle or leaking container;
- A reaction between two incompatible reagents while in storage;
- A process or experiment begins to react unpredictably or uncontrollably;
- An exposure to hazardous substances occurs that results in injury;
- A chemical fume hood that contains a toxic or hazardous substance fails to evacuate vapors from the hood; or
- A strong odor is detected and the origin cannot be determined or the release cannot be brought under control.

Each emergency event will be unique and will require assessment to determine the appropriate response. Laboratory personnel are not required to respond to laboratory emergency situations. An individual who is uncomfortable responding to an emergency situation should evacuate the laboratory and request assistance. If a situation poses imminent danger to health and safety and cannot be isolated, contained, or controlled, evacuate the room or building (if necessary) and contact University Police by dialing 911 from a university phone or 703-993-2810 from any phone. Above all else, laboratory personnel should take measures to ensure the safety of themselves and other laboratory personnel.

This section provides general information relevant to all laboratory emergencies and detailed procedures to be followed in the event of a chemical spill or exposure. Emergency response procedures for biological materials or radioactive materials are provided in the *Biological Safety Manual* and *Radiation Protection Plan*, respectively. In addition, the *Supplemental Laboratory Safety Plan* provides spill and exposure response procedures for the specific hazardous substances used in each laboratory

14.1 Emergency Preparedness

In preparing for laboratory emergencies, it is necessary to consider the type of work conducted in the laboratory and the most likely accidents that may occur. Laboratory personnel must know the appropriate emergency response procedures, the location and use of any emergency equipment, emergency contact information, and any necessary follow-up procedures. The required elements of emergency preparedness for laboratories are listed below:

- Along with the information provided in this manual, the *Supplemental Laboratory Safety Plan* must provide laboratory specific emergency response information. A template for completion of this plan is available on the EHS website.

- SDS for all chemicals in the laboratory must be readily available so that laboratory and emergency response personnel have immediate access to chemical specific emergency information.
- Emergency contact information must be clearly posted on the laboratory entrance sign.
- Emergency showers and eye washes must be flushed every two weeks by the departments and tested by EHS routinely so that they are operational in the event of an exposure.
- Spill supplies must be appropriately stocked and easily accessible.
- A first aid kit containing basic supplies must be stocked and easily accessible.
- Personnel should be familiar with the building evacuation plan and their laboratories evacuation route.

For additional information, please reference the EHS *Emergency Preparedness Program* guides on the EHS website. It is also recommended that laboratory personnel receive *Fire Extinguisher Training* (offered by EHS) first aid training, cardiopulmonary resuscitation training, and participate in fire, earthquake, and severe weather drills conducted by the university

14.2 Emergency Notification

When an emergency situation arises, contact University Police by dialing 911 from any university phone or 703-993-2810. Provide the following information:

- Name and telephone number;
- Location of the emergency (building name, room number, and building specific address, if known);
- Nature of the emergency (e.g., chemical spill and chemical(s) involved, fire, injuries); and
- Special considerations (e.g., the potential for explosion, acutely hazardous gases present, people trapped in rooms or buildings, number of people injured and type of injuries, electrical hazards, property damage and access routes to the emergency).

University Police will dispatch an officer(s) to the scene and notify EHS if necessary. University Police will secure the area, assist the injured, establish emergency communications, and control the situation until response personnel arrive.

14.3 Evacuation Procedures

The following procedures should be followed when a building must be evacuated:

1) Notify other laboratory personnel.
2) If conditions permit, cap and secure open vials, bottles, and other materials and turn off laboratory equipment and Bunsen burners or other sources of open flame.
3) Leave the laboratory and close the door.
4) Activate the fire alarm by using a manual pull station.
5) Notify University Police by dialing 911 from a university phone or 703-993-2810 from a university or cell phone and report the situation and associated details if known.
6) Do not use elevators during a fire or evacuation.

7) Assist individuals with special needs and those unfamiliar with evacuation procedures.
8) Exit the building by way of the nearest exist.
9) Assemble at the Designated Assembly Area and await further instruction from emergency response personnel.
10) Report missing persons to emergency response personnel.
11) Do not reenter the building until authorized to do so by University Police or emergency response personnel.

Additional information regarding emergency evacuation for fire or other emergencies is available in the *Emergency Evacuation Guide*.

14.4 Laboratory Fires

Personnel are not required to fight fires and should evacuate the building immediately in the event of a fire. University Police has the primary responsibility for responding to emergencies and must be notified immediately of such situations by calling 911 from any campus phone or 703-993-2810.

Employees may use fire extinguishers to fight small, incipient fires (no larger than a waste basket) only if they have been trained in the proper use of a fire extinguisher and are confident in their ability to cope with the hazards of a fire. In such cases, firefighting efforts must be terminated when it becomes obvious that there is danger from smoke, heat, or flames.

If a fire occurs in the laboratory:

1) Consider the following: cap and secure items on bench tops and in the chemical fume hood and turn off laboratory equipment.
2) Close the chemical fume hood if appropriate.
3) Leave the laboratory and close the door.
4) Activate the building fire alarm using a manual pull station located near an exit door.
5) Contact University Police by dialing 9-1-1 from a university phone or 703-993-2810 from a cell phone, and be prepared to give the exact location of the fire including campus, building address, building name, and cause of the fire. The building address and campus name are located on emergency exit route signs.
6) If you are confident that you can control the fire with a portable fire extinguisher and have been properly trained in the use of portable fire extinguishers, attempt to extinguish the fire if safety permits.
7) Never allow a fire to come between you and an exit. Assist individuals with disabilities and those who appear to need direction.
8) Evacuate the building as quickly as possible using the primary or alternate exit routes. Exit route signs are posted in conspicuous locations throughout university buildings. Alternate exit routes have been identified in case the primary evacuation route is obstructed by a hazard, is occupied by emergency response personnel, or cannot otherwise be used.
9) If you are unable to exit the building, trapped in an elevator, or mobility challenged, contact University Police by dialing 9-1-1 from a university phone or 703-993-2810 from a cell phone (if a phone is available) and await assistance.

10) Proceed to the designated assembly area and verbally warn others to evacuate the building as you exit the building.
11) If you are unable to exit the building due to fire, disability, or other hazard, notify a person that is exiting the building or notify police by dialing 9-1-1 from a university phone or 703-993-2810 from a cell phone, shout for assistance, drop an object to the ground from an exterior window, or hang a highly visible object from a window to get the attention of first responders.
12) Do not reenter the building until told to do so by University Police or the fire department.

Keep in mind these tips as you follow the steps listed above:

- Feel door handles with the back of your hand before opening a door(s).
- If the door handle is hot, don't open it. Go to a phone or window and call for help.
- If the handle is not hot, open it cautiously.
- Check for smoke, heat, or fire before going out.
- If smoke is present, stay as low as possible and crawl to an exit door. Keep one shoulder against the wall as you exit the building to avoid becoming lost.
- Do not use elevators.
- Knock on closed doors as you leave and yell "FIRE!" on your way out.
- Make note of the location of anyone who may have been unable or refused to evacuate.
- Report missing persons to emergency response personnel.

14.5 Spills and Accident Procedures

Chemical spills require proper response procedures that take into consideration the chemicals involved, their potential toxicity or chemical hazards, routes of exposure, and the potential for releases to the environment. The *Supplemental Laboratory Safety Plan* completed by PI/LS should outline laboratory-specific spill and accident response procedures for Particularly Hazardous Substances.

Laboratory personnel are not required to respond to a spill. An individual who is uncomfortable responding to a spill should contact EHS. EHS provides general spill procedure guidelines for chemical spills below. In addition, the *Biological Safety Manual* and *Radiation Protection Plan* provide procedures for handling spills involving biological or radioactive materials, respectively.

14.5.1 Spill Supplies

A spill kit is an essential safety item for all laboratories. EHS provides a basic spill kit to each laboratory. Contact EHS if additional supplies are needed.

PPE should also be used when responding to a spill. These items should already be available in each laboratory:

- Safety goggles;
- Gloves compatible with the substances used in the particular laboratory; and
- Lab coats.

14.5.2 Spill Response

If the spill involves acutely-toxic chemicals or chemicals of high-chronic toxicity, poses an inhalation hazard, or cannot be isolated, contained, or controlled quickly, evacuate the room.

1) Contact University Police for any spill that you suspect meets one of the following conditions:
    - Is greater than one gallon (four liters) or one kilogram;
    - Poses an inhalation hazard;
    - Cannot be isolated, contained, or controlled quickly;
    - Poses imminent danger to health and safety;
    - Poses imminent danger to property or the environment; or
    - You are uncomfortable responding to on your own.
2) Notify University Police by dialing 703-993-2810 or 911 from any university phone and provide the following details to the Police Dispatcher.
    - Your name;
    - Contact information;
    - Location of the spill;
    - Chemical(s) or product(s) involved;
    - Approximate quantity;
    - Injuries and/or property damage;
    - Status of the spill (e.g. contained, continued, abating, increasing, etc.); and
    - Any other information that can assist in identifying, containing, or responding to the spill.
3) University Police will contact EHS to respond to the spill and will contact additional emergency services if necessary.
4) Signal to others to leave, close the door, and post a warning sign.
5) Go to a support space or adjacent laboratory. Avoid the hallway and publicly accessed areas.
6) Remove contaminated PPE and clothing, turning exposed areas inward, and place in a polyethylene bag.
7) If a personal exposure has occurred or you experience symptoms of exposure, follow procedures outlined in Section 13.6 and contact EHS or University Police to handle spill response.
8) Call 911 for medical assistance, when needed.
9) If you can safely proceed in cleaning the spill, notify other laboratory personnel and consult the SDS regarding the physical, chemical, and toxicological properties and hazards of the chemical to determine the appropriate response.
10) Do not attempt to respond to a spill alone. Employ the assistance of a coworker to facilitate clean-up activities.
11) Assemble spill supplies and use appropriate PPE including lab coat, gloves, and eye or face protection.

Follow these steps when responding to a chemical spill that can be managed by laboratory personnel:

1) Contact EHS prior to responding to a chemical spill for assistance if needed.

2) Review the SDS to determine the appropriate PPE and cleanup procedures. If the SDS is unavailable, contact EHS for assistance. Do not respond to a spill unless you have reviewed the SDS. Refer to the following sections of the SDS for cleanup information:
    - Section 3 – Hazard Identification;
    - Section 6 – Accidental Release Measures; and
    - Section 8 – Exposure Control and Personal Protection.
3) Retrieve spill cleanup supplies and PPE. EHS has placed spill response equipment throughout the university; contact EHS for spill supplies and assistance.
4) Wear appropriate PPE as recommended by the SDS.
5) Check equipment and containers for leaks, damage, or holes. Place damaged or leaking containers in impervious secondary containment.
6) Surround the spill with absorbent materials to contain the spill and prevent further contamination.
7) If the spill is increasing in size, use absorbent or impervious material to block the most likely path the spilled material will take.
8) Ensure that spill cleanup equipment is compatible with the spilled chemical(s).
9) Start from the outside perimeter of the spill and begin absorbing the product using absorbent pads, booms, rags, or other media.
10) Collect all contaminated absorbent materials, PPE, and tools and place them in an appropriate rigid, sealable container or sturdy plastic bag.
11) Label the container holding the spill debris with a label that has both the date and the name of the spilled material(s) and include the words "Hazardous Waste."
12) Contact EHS to remove and dispose of the spill debris. Do not dispose contaminated cleanup materials in the municipal waste bins.

14.6 Personal Exposure

In the event of a personal exposure, an individual's primary concern must be to minimize the degree of exposure and the possible effects. The emergency procedures employed depend on the type of hazardous substance to which the individual was exposed and the extent of exposure. Immediate emergency response procedures for inhalation, ingestion, or skin exposure incidents are provided below. In general, laboratory personnel who have experienced an exposure should immediately:

1) Decontaminate affected areas using the exposure procedures outlined in the SDS.
    - If the situation requires immediate medical attention, immediately contact University Police by dialing 911 from a university phone or 703-993-2810 from a cell phone and relay the following information:
    - Nature of the injury or illness;
    - Victim's location;
    - Identity of the victim; and
    - Suspected or known cause of the injury or illness.
2) Provide first aid or medical assistance as necessary, if trained.
3) Do not move the victim if they are unconscious unless they are in immediate danger.
4) If the victim is unconscious and not breathing, locate an AED if available, turn it on and follow the instructions provided by the unit.
5) Remain with the victim until emergency response personnel arrive.

6) Do not provide first aid or CPR if not properly trained and certified to do so.
7) Students who have been exposed should report to Student Health Services. In the event that Student Health Services is closed, seek medical attention at the closest medical facility.
8) Faculty and staff should report to the nearest medical facility as listed on the *Supplemental Laboratory Safety Plan* associated with the lab where potential exposure occurred. (Note: Employees with health insurance through Kaiser Permanente should contact Kaiser Permanente to identify the medical provider.)
9) Immediately notify the PI/LS and EHS of the incident.
10) If you are a student, fill out an *Incident Report Form* and submit it to the Office of Risk Management; employees are required to submit a *First Report of Accident Form* to the Workers' Compensation department within Human Resources and Payroll.

Medical care as a result of work-related exposure may be provided at no cost to the employee and is dependent on the type of exposure. Facilities closest to the Fairfax and Prince William campuses are listed below.

Fairfax:

Med-First Urgent Care Center **
9452 Main Street
Fairfax, VA 22031
703-503-1112

Fair Oaks Hospital **
3600 Joseph Siewick Drive
Fairfax, VA 22033
703-391-3600

Fairfax Hospital **
3300 Gallows Road
Falls Church, VA 22042
703-776-3154

Inova Emergency Services **
4315 Chain Bridge Road
Fairfax, VA 22030
703-877-8200

Virginia Medical Acute Care (VMAC) **
5501 Backlick Road
Suite 105
Springfield, VA 22151
703-642-2273

Prince William:

Prince William Hospital **
8700 Sudley Road
Manassas, VA 20110
703-369-8000

AltMed
7524 Diplomat Drive
Suite 101
Manassas, VA 20109
703-361-4357

*** Provides 24-hour emergency medical care*

Students seeking medical care for nonlife-threatening injuries/illnesses may visit Student Health Services at one of the following three locations.

Fairfax	Prince William	Arlington
Student Union Building Room 214 Phone: 703-993-2831	Occoquan Building Room 229 Phone: 703-993-8374	Founders Hall Suite B-102 Phone: 703-993-4863

In the event of a life threatening injury/illness, contact emergency medical service personnel immediately. Do not attempt transport the individual to a medical facility. Wait for EMS to arrive.

14.6.1 Inhalation Exposure

Follow the steps below when there is a potential for inhalation exposure:

1) Stop breathing in order to avoid inhaling airborne substances, and quickly leave the room.
2) Signal to others to leave, close the door, and post a warning sign.
3) Go to a support space, adjacent laboratory, or outside for fresh air.
4) Remove contaminated PPE and clothing, turning exposed areas inward, and place in a polyethylene bag.
5) Review the SDS for the chemical involved to evaluate exposure data.
6) Call 911 for emergency medical assistance or seek medical attention at the closest medical facility listed above.
7) Call 911 for medical assistance or report to the closest medical facility, when needed.
8) Immediately notify PI/LS and EHS. EHS must clear the laboratory for reentry. If EHS is not available or it is after normal business hours, contact University Police.

14.6.2 Ingestion Exposure

In the event of accidental ingestion, seek medical attention (dial 911 or the Poison Control Center at 800-962-1253). Do not induce vomiting unless directed to do so by a healthcare provider. Immediately notify PI/LS and EHS. If EHS is not available or it is after normal business hours, contact University Police.

14.6.3 Skin or Mucous Membrane Exposure

Skin or mucous membrane exposure can occur through splashes to the eye, face, exposed skin, or clothing; by touching mucous membranes with contaminated hands; from a needle stick, puncture with a contaminated sharp object, an animal scratch or bite; or through wounds, abrasions, and eczema. In the event of a skin or mucous membrane exposure:

1) Remove contaminated PPE and clothing, turning exposed areas inward, and place in a polyethylene bag.
2) For mucous membrane exposure, flush the affected area with the eyewash for at least 15 minutes.

3) For skin exposure, wash affected skin with soap and cold water for at least 15 minutes. Cold water has the effect of closing the skins pores thereby slowing the rate of absorption into the body. Wash gently so as not to break the skin. For skin exposures not limited to the hands and forearms, the emergency shower should be used.
4) Call 911 for emergency medical assistance or seek medical attention at the closest medical facility listed above.
5) Immediately notify PI/LS and EHS. EHS must clear the laboratory for reentry. If EHS is not available or it is after normal business hours, contact University Police.

14.6.4 Hydrofluoric Acid Exposure

Laboratories that use or store hydrofluoric acid are required to have calcium gluconate in gel form or benzalkonium chloride treatment on hand in the event of a skin exposure. Calcium gluconate must be applied and massaged into the affected area with gloved hands as soon as possible in order to prevent permanent damage. If hydrogen fluoride vapors are inhaled, the victim must seek fresh air immediately and be provided prompt medical attention (call 911). In all cases of hydrofluoric acid exposure, victims should always seek medical attention. Spills involving hydrofluoric acid must not be handled by laboratory personnel; these spills must be managed by EHS.

14.6.5 Allergic Reaction

Laboratory personnel who experience a severe allergic reaction or show symptoms of allergic reaction while working in the laboratory should leave the work area immediately. If the reaction is caused by contact with the skin, wash the infected area(s) with profuse amounts of cool water. If the reaction is severe, seek immediate medical attention at the nearest medical facility. Before returning to work, laboratory personnel who have experienced an allergic reaction to a chemical should consult with the PI/LS and EHS.

14.6.6 Equipment Failures

Equipment failures can result from power failure, defects, or malfunctions. If a piece of equipment fails while in use, take steps to contain or control possible exposures to the substances being used. It is inappropriate to continue use of hazardous substances and equipment during a power failure or equipment malfunction. In the event of a power failure, all personnel must secure the materials they are working with, turn off equipment, and leave the laboratory until power is restored.

14.6.7 Gas Leaks

Situations involving uncontrollable leaking gas from a cylinder should be considered extremely hazardous and warrant immediate evacuation of the building. If the gas leak is minimal, innocuous, and safely within reach, the cylinder valve should be closed. Otherwise leave the area, call University Police by dialing 911 from a campus phone or 703-993-2810, and activate the fire alarm to evacuate the building.

If you are working with acutely-toxic or flammable gasses and suspect that a cylinder is leaking or gas is being released into the work area, evacuate the building immediately by activating the fire alarm. Once in a safe location, contact University Police.

14.7 Ventilation Failure

If laboratory building ventilation fails, all operations concerning chemicals within that laboratory or building must be discontinued. Laboratory operations may resume in the laboratory or building once ventilation has been restored and if it is confirmed that all ventilation systems are operating correctly. Chemical fume hoods that have failed cannot be used.

14.8 Emergency Drills

Fire Drills are conducted on campus in accordance with Section 405 of the SFPC. The purpose of fire drills is to evaluate the efficiency and effectiveness of faculty, staff, students, and visitors in carrying out emergency evacuation procedures. All laboratory personnel should be familiar with evacuation procedures for their building. Fire drills are conducted at least annually for all buildings that contain laboratories. The university also conducts annual earthquake, tornado, and severe weather drills. These drills are announced via the university's emergency notification system; participation is optional but strongly recommended.

Appendix A
Definitions

Action levels: A measured concentration of a hazardous chemical at which certain actions such as medical surveillance or routine air sampling are required if a person is exposed or has the potential to be exposed to the chemical in the measured concentration. This value is determined by OSHA and/or NIOSH and is typically half of the published PEL or TLV.

Acutely toxic chemicals: Chemicals that cause adverse health effects (target organ systems or cause death) as a result of a single dose or multiple exposures of short duration; 24 hours for oral and dermal exposure, and four hours for exposure by inhalation.

Administrative controls: Work procedures, such as written safety policies, rules, supervision, and training, with the goal of reducing the duration, frequency, and severity of exposure to hazardous chemicals or situations.

Aerosol: Tiny particles or droplets suspended in air.

Affiliate: A person who is not a George Mason University employee, faculty, staff, or student but is participating in laboratory activities in facilities owned or under the control of George Mason University. This includes volunteers, visiting faculty, and visiting research associates.

Biohazardous material: All infectious agents, vectors known to carry and transmit infectious agents, infected or potentially-infected animals, infectious material, recombinant deoxyribonucleic acid (DNA), and biologically-derived toxins that present either a risk or a potential risk to the health of humans, animals, or plants either directly through infection or indirectly through damage to the environment.

Biological Inventory: List of all biological materials present, used, or stored in the laboratory.

Biological material: As used in this manual, a general term referring to all prokaryotic and eukaryotic organisms (and their components), viruses, subviral agents, recombinant DNA, and biologically-derived toxins used in research and instructional laboratories.

Biological Safety: (see Biosafety)

Biosafety: A concept that promotes safe laboratory practices, procedures, and proper use of containment equipment and facilities by laboratory personnel in the research and instructional laboratory environment. The purpose of a biological safety program is to prevent laboratory-acquired infections.

Biosafety cabinet: A device enclosed (except for necessary exhaust purposes) on three sides and top and bottom, designed to draw air inward by means of mechanical ventilation, operated with insertion of only the hands and arms of the user, and in which pathogens are used.

Bloodborne pathogens: (as defined by OSHA) Pathogenic microorganisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus (HBV) and human immunodeficiency virus.

Carcinogen: (see select carcinogen)

Ceiling limit: The maximum concentration or dose of a hazardous chemical that a person should never be exposed to for any period of time.

Chemical emergency: (as defined by OSHA in 29 CFR 1910.1450) An equipment failure, rupture of containers, or failure of control equipment that results in an uncontrolled release of a hazardous chemical into the workplace.

Chemical fume hood: (as defined by OSHA in 29 CFR 1910.1450) Device located in a laboratory, enclosed 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 individual's body other than hands and arms.

Chemical Hygiene Officer: (as defined by OSHA in 29 CFR 1910.1450) 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 employee shall hold within the employer's organizational structure.

Chemical Hygiene Plan: (as defined by OSHA in 29 CFR 1910.1450) A written program developed and implemented by the employer which sets forth procedures, equipment, PPE 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 29 CFR 1910.1450.

Chemical waste: Solid or liquid laboratory waste-containing chemicals that must be disposed of through George Mason University's chemical waste management program.

Chronically Toxic Chemical: A chemical that can produce adverse health effects through repeated exposure. Long-term exposure to chronically-toxic chemicals can result in localized or systemic damage.

Code of Federal Regulations (CFR): The codification of the general and permanent rules and regulations published in the Federal Register by the executive departments and agencies of the Federal Government.

Corrosive: Having a pH less than 2, or greater than 12.5, or the ability to cause irreversible damage to the skin within four hours of exposure, or exhibit corrosion on either steel or aluminum surfaces exceeding 6.25mm per year at a test temperature of 55 °C (130 °F).

Decontamination: Process by which contaminated surfaces, equipment, instruments, or waste are rendered nonhazardous.

Designated area: (as defined by OSHA in 29 CFR 1910.1450) an area which may be used for work with select carcinogens, reproductive toxins, or substances which have a high degree of acute toxicity (Particularly Hazardous Substances). A designated area may be the entire laboratory, an area of a laboratory, or a device such as a laboratory hood.

Dose: A quantity of a toxic substance that is absorbed by an individual. Dose is reported in milligrams (mg) of toxicant per kilograms (kg) of body weight (mg/kg) for acute exposures and in mg/kg per day for repeat-dose exposures.

Employee: A person who works for the university full-time or part-time and is paid through George Mason University's payroll system or receives compensation in any form from the university.

Engineering controls: Controls that eliminate or reduce exposure to laboratory hazards through the use or substitution of engineered machinery or equipment. Examples include self-capping syringe needles, ventilations systems such as a chemical fume hood, sound-dampening materials to reduce noise levels, safety interlocks, and radiation shielding.

Explosive: (as defined by OSHA in 29 CFR 1910.1450) A chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

Exposure incident: An event that results in the direct physical contact of an individual with a hazardous substance via one of the following routes: inhalation, ingestion, absorption, or injection.

Face velocity: A measurement of the average velocity at which air is drawn through the front of the chemical fume hood to the hood exhaust.

Faculty: An employee who is appointed as a member of the instructional, research, or administrative faculty, including visiting faculty and post-doctoral fellows.

Flammable liquids: [as defined by The Globally Harmonized System of Classification and Labelling of Chemicals (GHS)] Chemicals with a flashpoint less than 93°C (200°F).

Flashpoint: (as defined by GHS) the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. The lower the flash point, the easier it is to ignite the material.

Hazardous chemical: (as defined by OSHA in 29 CFR 1910.1450) is a chemical "which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified." The term "health hazard" includes chemicals which are carcinogens, toxic or highly-toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system, and agents that damage the lungs, skin, eyes, or mucous membranes.

Hazardous material: (as defined by DOT in 49 CFR 171) A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported.

Hazardous substance: Any material that may present a danger to human health and welfare or the environment. This includes hazardous chemicals, biohazardous materials, and sources of ionizing radiation.

Hazardous waste: A waste with properties that make it dangerous or potentially harmful to human health or the environment and exhibits at least one of four characteristics: ignitability, corrosivity, reactivity, or toxicity.

Heavy metal: A metal whose specific gravity is approximately 5.0 or higher (e.g., arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver).

High Efficiency Particulate Air (HEPA) filter: Filters that have an efficiency of 99.97% for particles of 0.3 microns.

Infectious agents: All human, animal, and plant pathogens (bacteria, parasites, fungi, viruses, prions).

Infectious material: Infectious agents and all biological material that contains or has the potential to contain infectious agents. Examples of infectious material include regulated medical waste, human blood and blood components, human tissues and body fluids, cultured cells (from humans and nonhuman primates), infected animals and animal tissues, nonhuman primates and any tissues from nonhuman primates (can transmit HBV), sheep and any tissues derived from sheep (can transmit Coxiella burnetti, causative agent of Q-fever), and environmental samples likely to contain infectious agents.

Inhalation lethal concentration (LC50): (as defined by OSHA in 29 CFR 1910.1200) The calculated concentration of a material in air, which based on laboratory tests (respiratory route) is expected to kill 50% of a group of test animals when administered as a single exposure in a specific time period, usually one hour.

Injection: A puncture of the skin resulting from contact with a sharp object that has the potential to carry a hazardous substance into the body.

Instructional laboratory: Facility located on George Mason University property that meets the requirements for a laboratory and where academic laboratory courses are conducted.

Ionizing radiation: Radiation capable of displacing electrons from atoms or molecules, thereby producing ions.

Laboratory: (as defined by OSHA in 29 CFR 1910.1450) 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 nonproduction basis. At George Mason University, "laboratory" is used to define instructional areas where small quantities of *chemicals* are used during instructional course on a nonproduction basis.

Laboratory personnel: Faculty (professional, administrative, and research), staff (classified, wage, and student wage), affiliates (visiting faculty, volunteers, visiting research associates), and students (graduate students, undergraduate students, laboratory assistants, etc.) working in laboratories and laboratory support areas. This term does not refer to students enrolled in instructional laboratory courses.

Laboratory support room: Space auxiliary to a laboratory that is used by laboratory personnel to prepare reagents or store materials for their laboratory.

Lecture bottle: A small compressed gas cylinder, typically 2 or 3 inches in diameter and 12-18 inches in height. Lecture bottles typically contain acutely-toxic or extremely-hazardous substances.

Lethal dose 50 (LD50): (as defined by OSHA in 29 CFR 1910.1200) The estimated single dose of material which, based on laboratory tests, is expected to kill 50% of a group of test animals. The material may be administered orally or applied to the skin. The LD50 dose is usually expressed as milligrams or grams of material per kilogram of animal body weight (mg/kg or g/kg).

Local effect: Health effect restricted or limited to an effect at or close to the site of contact.

Medical consultation: (as defined by OSHA in 29 CFR 1910.1450) 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.

Odor threshold: The lowest concentration, measured in ppm, of a chemical in the air that is detectable by smell.

Organic peroxide: (as defined by OSHA in 29 CFR 1910.1450) 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. ***The term also includes organic peroxide formulations (mixtures).***

Oxidizing material: (as defined by OSHA in 29 CFR 1910.1450) 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.

Particularly Hazardous Substances: A subset of hazardous chemicals that OSHA has identified as requiring special consideration and additional safety provisions because of their toxic effects. Select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity are Particularly Hazardous Substances.

Permissible Exposure Limits (PEL): Limits set by OSHA to protect personnel against the health effects of exposure to hazardous substances. PEL are regulatory limits on the amount of concentration of a substance in the air. They may also contain a skin designation. PEL are enforceable. OSHA PEL are based on an eight-hour TWA exposure.

Personal Protective Equipment (PPE): Clothing and other work accessories designed to create a barrier against workplace hazards and protects only the individual.

Physical hazard: (as defined by 29 CFR OSHA 1910.1200) A chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive), or water-reactive.

Physical properties: Characteristics of a substance such as melting point, freezing point, specific gravity, or density, which cannot be changed without chemically altering the substance.

P-listed waste: Specific commercial chemical products in a pure or unused form that are acutely hazardous to human health and are highly regulated by the EPA. (A list of these chemicals can be found in 40 CFR 261.33.)

Radioactive waste: Liquid and solid laboratory waste that contains radioactive material.

Reactive: (as defined by OSHA in 29 CFR 1910.1450) A chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure, or temperature.

Reproductive toxins: (as defined by OSHA in 29 CFR 1910.1450) Chemicals which affect reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

Research laboratory: A facility located on George Mason University property that meets the requirements for a laboratory and where scientific research is conducted.

Restricted area: An area that contains unique hazards (e.g., animal rooms, hazardous waste storage, radioactive materials use spaces) and therefore requires more stringent access restrictions than other laboratories or laboratory support rooms.

Risk Group (RG1-4): Categories for biological agents (including unknown samples and environmental samples) that classify agents based on their relative degree of pathogenicity in

healthy human adults, mode of transmission and host range, availability of preventative measures and the availability of effective treatment. Risk groups take into account the risk posed to laboratory personnel and the community.

Safety Data Sheet (SDS): A standard formatted information sheet prepared by a material manufacturer, describing the potential hazards, physical properties, and procedures for safe handling, storage, and disposal of a material.

SDS Library: Binder or book present in each laboratory that contains SDS for each chemical and biohazardous material present in the laboratory.

Satellite Accumulation Area: (as defined in 40 CFR 262.34(c)(1)) A storage location at or near any point of generation where hazardous wastes initially accumulate, which is under the control of the operator of the process generating the waste.

Secondary containment: A system or container that is capable of capturing any material that is discharged or has leaked from the primary container to prevent exposure, contact with the environment, or damage property for the anticipated period of time necessary to detect and recover the discharged material.

Select agent: Biological agent or toxin that could pose a severe threat to public health and safety, to animal or plant health, or animal or plant products, and are therefore covered under the Select Agent Rule.

Select carcinogen: (as defined by OSHA in 29 CFR 1910.1450) 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 (latest edition); or (iii) It is listed under Group 1 ("carcinogenic to humans") by the 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 the National Toxicology Program, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria: (A) after inhalation exposure of six-to-seven hours per day, five 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.

Sensitizers: 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.

Staff: An employee who is not a member of the faculty or a student.

Student: A person who is officially enrolled in a course or program of study offered by George Mason University.

Systemic effects: Health effects that involve tissues or organs unrelated to or removed from the site of contact with the material.

Short term exposure limit: The maximum concentration personnel can be exposed to for fifteen minutes without suffering from irritation, chronic or irreversible tissue damage, or narcosis of sufficient degree to cause impairment.

Threshold limit value (TLV): Guidelines prepared by the ACGIH to assist industrial hygienists in making decisions regarding safe levels of exposure to various hazards found in the workplace. A TLV reflects the level of exposure that a typical worker can experience without an unreasonable risk of disease or injury. TLV are not quantitative estimates of risk at different exposure levels or by different routes of exposure.

Toxicity: The ability of a chemical to cause an undesirable effect in a biological system.

Time weighted average (TWA): The concentration of an airborne chemical averaged over an eight-hour workday to which personnel may be exposed to daily without sustaining injury.

Unit: Organizational entity (e.g., office, department, college, center, institute, school, or affiliate organization) at George Mason University.

Vapor pressure: The pressure exerted by a vapor in equilibrium with the solid or liquid phase of the same substance. The partial pressure of the substance in the atmosphere above the solid or liquid.

Visitor: A person that is not a George Mason University employee, faculty, staff, affiliate, or student but whose work requires them to enter laboratories, laboratory support spaces, or secured or restricted laboratory areas.

Appendix B
Supplemental Laboratory Safety Plan

Supplemental Laboratory Safety Plan
George Mason University

Under 29 CFR 1910.1450, George Mason University is required to provide a Chemical Hygiene Plan that establishes minimum safety standards for working with chemicals in the laboratory and outlines procedures that minimize both the risk of chemical exposure to laboratory personnel and the risk of chemical releases into the environment. Additionally, under 29 CFR 1910.1030, the university is required to establish an Exposure Control Plan designed to minimize or eliminate the risk of exposure to infectious materials which is available on the Environmental Health and Safety (EHS) webpage, ehs.gmu.edu. The *Laboratory Safety Manual* serves as the Chemical Hygiene Plan for George Mason University, and the *Biological Safety Manual* outlines safety practices to minimize the risk of exposure to infectious or potentially infectious materials in laboratories.

The *Supplemental Laboratory Safety Plan* is a supplement to the *Laboratory Safety Manual* and *Biological Safety Manual* that provides laboratory-specific information for responding to health and safety issues and laboratory emergencies. The plan, which must be completed for all laboratories, must list the types of hazards present in the laboratory and outline laboratory-specific engineering and administrative controls, personal protective equipment (PPE), operational procedures (e.g., decontamination, waste handling), and procedures for spill or exposure response. The *Supplemental Laboratory Safety Plan* must be kept in the *Safety Records and Resources* binder located within the laboratory where it is readily available to laboratory personnel and must be routinely reviewed and updated to reflect current laboratory activities. A copy should also be on file with EHS. The template for completing this plan is available on the EHS website (ehs.gmu.edu). Laboratory personnel must be trained on the contents of this plan and must verify receipt of training by signing the *Laboratory Training Signature* page, also located within the *Safety Records and Resources* binder and on the EHS website (ehs.gmu.edu).

General Information

Date modified:

Principal Investigator or Laboratory Supervisor: _____

Unit or Department: _____

Office Location: _____ **Office Phone: _____**

Lab Location: _____ **Lab Phone: _____**

Email Address: _____

Emergency Response Procedures

1. Emergency Contact Information

University Police:	911 from a university phone or (703) 993-2810
Environmental Health and Safety:	703-993-8448
PI/LS after hours contact #:	_____
Other: _____	_____
Other: _____	_____
Other: _____	_____

2. Local Medical Care Facilities

Fairfax Campus:

1) Inova Emergency Care Center
4315 Chain Bridge Road, Fairfax, VA 22030
703-877-8200

2) Inova Fairfax Hospital
3300 Gallows Road, Falls Church, VA 22042
703-776-4002

Prince William Campus:

Prince William Hospital Emergency Room
8700 Sudley Road, Manassas, VA 20110
(703)-369-8000

3. Emergency Equipment available in or near the laboratory

Eye wash location: _____	Flushed every two weeks by: _____
Emergency shower location: _____	Flushed every two weeks by: _____
Fire extinguisher location: _____	Fire extinguisher type: _____
Spill supplies location: _____	First aid kit location: _____
Other: _____	Other: _____

4. Emergency Notification

- Contact University Police by dialing 911 from any university phone or (703) 993-2810.
- Provide the following information:
  - Name and telephone number of the caller.
  - Location of the emergency (building name, room number, and building specific address, if known).
  - Nature of the emergency (e.g., chemical spill and chemical(s) involved, fire, injuries).

Special considerations (e.g., the potential for explosion, acutely hazardous gases present, people trapped in rooms or buildings, number of people injured and type of injuries, electrical hazards, property damage and access routes to the emergency).

5. Evacuation Procedure (Follow these steps, if safe to do so.)

1. Notify other laboratory personnel.
2. If conditions permit, cap and secure open vials, bottles, and other materials and turn off laboratory equipment.
3. Leave the laboratory and close the door.
4. Activate the fire alarm to evacuate the building.
5. If it is safe to do so, assist anyone who may be in danger. Otherwise notify emergency response personnel once you have evacuated the building.
6. Exit the building according to the Building Evacuation Plan in a calm manner using the closest available emergency exit. Never use elevators.
7. Congregate at the pre-designated assembly point for the building.

6. Laboratory Fire (Personnel are not required to fight fires and should evacuate the building immediately in the event of a fire.)

1. Notify other laboratory personnel.
2. If conditions permit, cap and secure open vials, bottles, and other materials and turn off laboratory equipment.
3. Leave the laboratory and close the door.
4. Activate the fire alarm to evacuate the building.
5. If it is safe to do so, assist anyone who may be in danger. Otherwise notify emergency response personnel once

you have evacuated the building.

6. Notify University Police or emergency response personnel that you have specific information regarding the fire.
7. Fight a fire with a fire extinguisher **ONLY IF**:
    a. You have been trained in the proper use of a fire extinguisher and are confident in your abilities to cope with the hazards of the fire.
    b. The fire is a small, incipient fire (no larger than a waste basket).
    c. Terminate fire fighting efforts when it becomes obvious that there is a danger from smoke, heat, or flames.

7. Gas Leaks

Situations involving uncontrollable leaking gas from a cylinder should be considered extremely hazardous and warrant immediate evacuation of the building. If the gas leak is minimal, innocuous, and safely within reach, the cylinder valve should be closed. Otherwise leave the area, call University Police by dialing 911 from a campus phone or 703-993-2810, and activate the fire alarm to evacuate the building.

8. Equipment Failures

Equipment failures can result from power failure, defects, or malfunctions. If a piece of equipment fails while in use, take steps to contain or control possible exposures to the substances being used. It is inappropriate to continue use of hazardous substances and equipment during a power failure or equipment malfunction. In the event of a power failure, all personnel must secure the materials they are working with, turn off equipment, and leave the laboratory until power is restored.

9. Ventilation Failure

If laboratory building ventilation fails, all operations concerning chemicals within that laboratory or building must be discontinued. Laboratory operations may resume in the laboratory or building once ventilation has been restored and it is confirmed that all ventilation systems are operating correctly. Chemical Fume hoods that have failed can not be used until they are repaired and re-tested.

10. Other: List other probable emergencies for your laboratory and appropriate emergency response for laboratory personnel.

Exposure Response

11. Exposure Response–Skin or Mucous Membrane

In the event of a personal exposure, an individual's primary concern must be to minimize the degree of exposure and the possible effects. Skin or mucous membrane exposure can occur through splashes to the eye, face, exposed skin, or clothing; by touching mucous membranes with contaminated hands; or from a needlestick, puncture with a contaminated sharp object, an animal scratch or bite, or through wounds, abrasions, and eczema. **A general exposure response is provided below. This response may not be adequate for all materials present in the laboratory. Please provide additional exposure response procedures, as necessary, for chemicals and biological agents that require a specific exposure response.**

Chemical or Biological Agent:	**Exposure Response:**
General	1. Remove contaminated PPE and clothing, turning exposed areas inward and place in a bag. Dispose as laboratory waste. 2. Notify other laboratory personnel of the incident and of any surface or equipment decontamination that needs to be done. 3. For mucous membrane exposure, flush the affected area with the eyewash for at least 15 minutes. 4. For skin exposure, wash affected skin with soap and cold water for at least 15 minutes. Cold water has the effect of closing the skins pores thereby slowing the rate of absorption into the body. Wash gently so as not to break the skin. For skin exposures not limited to the hands and forearms, the emergency shower should be used. Apply first aid as needed. 5. Call 911 for emergency medical assistance or seek medical attention at the closest medical facility listed above. 6. Report all possible exposure incidents to PI/LS and EHS. 7. Complete and submit a *First Report of Accident Form* to the Workers' Compensation department within Human Resources and Payroll.

12. Exposure Response-Inhalation

Inhalation exposure can occur when working with volatile chemicals in a poorly ventilated area or as the result of inhaling airborne substances aerosolized by laboratory procedures such as centrifugation or vortexing. **A general exposure response is provided below. This response may not be adequate for all materials present in the laboratory. Please provide additional exposure response procedures, as necessary, for chemicals and biological agents that require a specific exposure response.**

Chemical or Biological Agent:	**Exposure Response:**
General	1. Stop breathing in order to avoid inhaling airborne substances and quickly leave the room. 2. Signal to others to leave, close the door, and post a warning sign. 3. Leave the area immediately and seek fresh air. 4. Remove contaminated PPE and clothing, turning exposed areas inward and place in a polyethylene bag. 5. Review the Safety Data Sheets (SDS) for the chemical involved to evaluate exposure data. 6. Call 911 for emergency medical assistance or seek medical attention at the closest medical facility listed above. 7. Report all possible exposure incidents to PI/LS and EHS. 8. Notify EHS who must clear the laboratory for re-entry. If EHS is not available or it is after normal business hours, contact University Police. 9. Complete and submit a *First Report of Accident Form* to the Workers' Compensation department within Human Resources and Payroll.

13. Exposure Response–Ingestion

Accidental ingestion may occur as a result of splashes to the face, touching the face with contaminated hands, eating, drinking, or applying cosmetics in the laboratory, or through the out-dated and unacceptable practice of mouth pipetting. **A general exposure response is provided below. This response may not be adequate for all materials present in the laboratory. Please provide additional exposure response procedures, as necessary, for chemicals and biological agents that require a specific exposure response.**

Chemical or Biological Agent:	**Exposure Response:**
General	In the event of accidental ingestion of a chemical, seek medical attention (dial 911 or the Poison Control Center at 800-962-1253). Do not induce vomiting unless directed to do so by a health care provider. Report all possible exposure incidents to PI/LS and EHS and and submit a *First Report of Accident Form* to the Workers' Compensation department within Human Resources and Payroll.

Spill Response

14. Spill Response

Laboratory personnel are not required to respond to a spill. If you are uncomfortable in responding to a spill, if a spill poses imminent danger to health and safety or cannot be isolated, contained or controlled, move to a safe area and contact University Police. Do not attempt to clean the spill.

Spill Supplies Available in the Laboratory

☐ Spill Kit containing absorbent material (pads, sheets, spill socks), nitrile gloves, polyethylene bags, boundary marking tape, disinfectant (that is most effective and appropriate for killing or inactivating the specific organisms stored and used in the particular laboratory), spray bottle, red biohazard autoclave bags for the collection of contaminated items, autoclave tape, tongs, sharps container, warning sign, spill supply inventory, and 5-gallon pail with screw top lid.

☐ Other Absorbent:
☐ Acid Neutralizer
☐ Caustic Neutralizer
☐ Other:

15. Spill Response-Chemical Spills

A general spill response is provided below. This response may not be adequate for all chemicals present in the laboratory. Please provide additional spill response procedures, as necessary, for chemicals that require a specific spill response.

Chemical or Biological Agent:	**Spill Response:**
General	1. Contact University Police for any spill that: • poses an inhalation hazard. • cannot be isolated, contained, or controlled quickly. • poses imminent danger to health and safety. • poses imminent danger to property or the environment. • you are uncomfortable responding to on your own. 2. Signal to others to leave, close the door, and post a warning sign. 3. Go to a support space or adjacent laboratory. Avoid the hallway and publicly accessed areas. 4. Remove contaminated PPE and clothing, turning exposed areas inward and place in a polyethylene bag. 5. If a personal exposure has occurred or you experience symptoms of exposure, follow exposure procedures in this plan and contact University Police. 6. Call 911 for emergency medical assistance or seek medical attention at the closes medical facility listed above. 7. If you can safely proceed in cleaning the spill, notify other laboratory personnel and consult the SDS regarding the physical, chemical, and toxicological properties and hazards of the chemical to determine the appropriate response. 8. Do not attempt to clean a spill alone. Employ the assistance of a co-worker to facilitate cleanup activities. 9. Assemble spill supplies and use appropriate PPE including lab coat, gloves, and eye or face protection. 10. Take steps to limit the impact of the spill by preventing spilled substances from reaching drains and by isolating equipment and materials that may escalate the danger of the situation. 11. Contain the spill with absorbent materials. 12. Pick up any visible sharp objects with tongs and discard into a sharps container. 13. Clean the spill by working from the outer edges of the spill towards the center. 14. Clean surrounding areas (where the spill may have splashed). 15. Clean contaminated laboratory equipment as needed. 16. Place the waste generated from cleaning the spill and contaminated PPE in a polyethylene bag. Place the bag into a sturdy pail such as the one provided with the

spill kit. Label the container with a Hazardous Waste label and place the waste in the satellite accumulation area. Sharps containers labeled with a biohazard symbol must be disposed of as biohazardous waste.
17. Wash hands with soap and warm water.
18. Report all possible exposure incidents to PI/LS and EHS and follow the exposure response outlined above.
19. Submit completed a *First Report of Accident Form* to the Workers' Compensation department within Human Resources and Payroll.

16. Spill Response–Biological Materials

When a biological spill occurs, it is important to understand the potential routes of exposure for the material involved and to employ proper response procedures. **A general spill response is provided below. For each infectious material in the laboratory, indicate the appropriate disinfectant, concentration and contact time required to clean the spill.**

1. If the biological material involved poses an inhalation hazard, stop breathing in order to avoid inhaling airborne material and quickly leave the room.
2. Signal to others to leave, close door, and post a warning sign. No one should enter the laboratory for 30 minutes.
3. Go to a support space or adjacent laboratory. Avoid the hallway and publicly accessed areas.
4. Remove contaminated PPE and clothing, turning exposed areas inward and place in a biohazard bag.
5. If a personal exposure has occurred, follow procedures outlined above and contact EHS or University Police to handle spill response.
6. Call 911 for medical assistance, when needed.
7. If the nature of the spill requires the use of a HEPA filtered respirator, do not attempt to handle the spill. EHS will assume responsibility for the situation. If the microorganism does not pose an inhalation threat and you are qualified and comfortable cleaning up the spill, proceed to the next step.
8. Assemble spill supplies and use appropriate PPE including lab coat, gloves, and eye or face protection.
9. Cover the area of the spill with disinfectant-soaked towels, and carefully pour disinfectant around the spill. Because the volume of the spill will dilute the disinfectant, a concentrated disinfectant should be used. Allow at least a 20-minute contact time.
10. Pick up any visible sharp objects with tongs and discard in a sharps container.
11. Wipe surrounding areas (where the spill may have splashed) with disinfectant.
12. Disinfect contaminated laboratory equipment as needed.
13. Treat contaminated spill supplies and PPE as biohazardous waste.
14. Wash hands with antiseptic soap and warm water.
15. Report all possible exposure incidents to PI/LS and EHS.
16. Notify EHS of the incident.
17. Submit completed *First Report of Accident Form* to the Workers' Compensation department within Human Resources and Payroll.

Infectious Material	Disinfectant	Concentration	Contact Time (min)

17. Spill Response-Centrifuge Spills

1. If a centrifuge malfunctions while in operation or a tube breaks, turn the centrifuge off immediately and unplug it (if you can do so easily).
2. If you notice a spill has occurred after opening the centrifuge lid, stop breathing in order to avoid inhaling airborne material and close the centrifuge to allow aerosols to settle.
3. Leave the laboratory and signal for others to leave the laboratory.
4. Go to a support space or adjacent laboratory. Avoid the hallway and publicly accessed areas.
5. Remove contaminated PPE and clothing, turning exposed areas inward and place in a biohazard bag.
6. If a personal exposure has occurred, follow procedures outlined above and contact University Police to handle spill response.
7. Call 911 for emergency medical assistance or seek medical attention at the closest medical facility listed above.
8. If the nature of the spill requires the use of a HEPA filtered respirator, do not attempt to handle the spill. EHS will assume responsibility for the situation. If the microorganism does not pose an inhalation threat and you are

qualified and comfortable cleaning up the spill, proceed to the next step.

9. Assemble spill supplies and use appropriate PPE including lab coat, gloves, and eye or face protection.
10. Remove rotor and place it in the biosafety cabinet. Open rotor, remove tubes using tongs or forceps. Disinfect the rotor with an appropriate chemical disinfectant and contact time. Dry the rotor thoroughly after disinfection.
11. Cover the bottom of the centrifuge with disinfectant-soaked towels. Concentrated disinfectant should be used. Allow at least a 30-minute contact time.
12. Wipe the inside of the centrifuge and the lid with an appropriate disinfectant. Dry the inside of the centrifuge thoroughly.
13. Treat contaminated spill supplies and PPE as biohazardous waste.
14. Wash hands with antiseptic soap and warm water.
15. Report all possible exposure incidents to PI/LS and EHS.
    Submit completed *First Report of Accident Form* to the Workers' Compensation department within Human Resources and Payroll.

Administrative Controls, Engineering Controls, and PPE

18. Administrative Controls
List any laboratory specific administrative controls in addition to those listed in the *Laboratory Safety Manual* and *Biological Safety Manual*

19. Safety and Compliance Bins Contain:

- ☒ Laboratory Safety Manual
- ☐ Biological Safety Manual
- ☐ Radiation Protection Plan
- ☐ SDS Library (For libraries too large to fit in the wall bins, list the location):
- ☐ Chemical Inventory
- ☐ Biological Inventory
- ☒ Laboratory Training Signature Page

20. Facility Requirements
List any laboratory specific facility requirements in addition to those outlined in the *Laboratory Safety Manual* and *Biological Safety Manual* (example: hands-free sink).

Safety Equipment Available:

- ☐ Biosafety cabinet ☐ Not ducted ☐ Ducted
- ☐ Chemical fume hood
- ☐ Glove box
- ☐ Sealed lids for centrifuge rotors
- ☐ Safe needle devices
- ☐ Other:

21. Location of Designated Areas

Chemical Storage:
Satellite Accumulation Area:
Radiation Usage Areas:
Other:

22. Personal Protective Equipment (PPE)
Check each type of PPE available for use in the laboratory. Equipment should be inspected, cleaned, or replaced as needed.

- ☐ Disposable lab coat
- ☐ Laundered lab coat
- ☐ Chemical resistant apron
- ☐ Disposable shoe covers
- ☐ Disposable sleeves
- ☐ Hair covering
- ☐ Glove liners
- ☐ Utility/autoclave gloves
- ☐ Animal-handling gloves
- ☐ Disposable gloves
  - ☐ Powder-free
  - ☐ Latex-free
  - ☐ Chemical-resistant
- ☐ Safety goggles
- ☐ Safety glasses
- ☐ Face shield
- ☐ Hearing protection
- ☐ Respiratory Protection
- ☐ Other:
- ☐ Other:

Infectious Material

23. Infectious material includes infectious agents (bacteria, parasites, fungi, viruses, prions) and all biological material that contains or has the potential to contain infectious agents. Examples include human blood and blood components, human tissues and body fluids, cultured cells from human and non-human primates, infected animals and animal tissues, non-human primates and any tissues from non-human primates, tissues from sheep, and environmental samples likely to contain infectious agents. Check all materials present in the laboratory.

- ☐ Human blood or blood components
- ☐ Other human bodily fluids (list):
- ☐ Unfixed human tissues or organs
- ☐ Fixed human or animal brain/neural specimens
- ☐ Experimental animal blood, organs, or tissue
- ☐ Infectious materials listed on the Biological Inventory (primary and continuous cell lines, bacteria (including chlamydial and rickettsial agents), viruses, fungi, parasites, subviral agents, etc.)

24. Exposure Determination

The following job classifications are at risk for exposure to infectious material in this laboratory:

- ☐ Faculty (Professional, administrative, research)
- ☐ Staff (classified, wage, student wage)
- ☐ Visiting Faculty
- ☐ Volunteers
- ☐ Visiting Research Associates
- ☐ Other:
- ☐ Post doctoral Fellows
- ☐ Graduate Students
- ☐ Undergraduate students
- ☐ Students working for credit
- ☐ High School Students
- ☐ Other:

25. The following activities place individuals at risk for exposure to infectious material**:**

- Handling or manipulating samples containing infectious material or potentially infectious material
- Using equipment potentially contaminated with infectious material
- Performing maintenance on equipment, instruments, or machinery potentially contaminated with infectious material
- Responding to spills involving infectious material
- Handling waste potentially contaminated with infectious material
- Packaging infectious material for shipping or transport

26. Certain tasks and procedures increase the risk of exposure. Check each of the following tasks or procedures performed by laboratory personnel:

- ☐ Use of sharps (needles, scalpels, blades, glass thermometers, pipettes, slides and coverslips)
- ☐ Injections or perfusions
- ☐ Use of french press, sonicator, homogenizer, or safety blender
- ☐ High speed centrifugation
- ☐ Dissection (human and non-human primate tissues and organs, any intentionally infected tissue or organ)
- ☐ Use of microtome or cryostat
- ☐ Pipetting, mixing, vortexing, or homogenization
- ☐ Handling infected animals and working in animal rooms containing infected animals

27. List other tasks, procedures, and activities that increase the exposure risk for laboratory personnel.

28. Laboratory Procedures

The *Biological Safety Manual* outlines general laboratory practices for work involving infectious materials, including a discussion of Universal Precautions to be followed when working with materials of human origin. List any additional laboratory specific practices and procedures in place for this laboratory (example: no sharps or glass permitted).

29. Decontamination Procedures

The *Biological Safety Manual* outlines general practices for decontamination and disinfection of infectious material. List the types of disinfectants used in the laboratory as well as the optimal concentration and contact time in number 16 above.

30. Waste handling procedures

The *Biological Safety Manual* outlines procedures for handling infectious waste. Additionally, EHS provides waste supplies (sharps containers, bags, burn boxes, etc.) upon request. Please provide laboratory specific waste handling information in number 16 above.:

Particularly Hazardous Substances

31. Particularly Hazardous Substances: List select carcinogens, acutely toxic chemicals, and reproductive toxins used in the laboratory and provide information on the storage and usage location, the type of containment devices used (e.g., chemical fume hood, glove box), the method used for decontamination, and specific waste handling procedures (e.g., location of waste receptacles). Provide information for each Particularly Hazardous Substance located in the laboratory.

Chemical Name	Designated Areas		Containment Devises used	Decontamination Procedures	Specific Waste Handling Procedures (disposal of liquid waste, paper trash, PPE, and other contaminated materials)
	Storage	Usage			

Animal Handling

32. Animal Handling: Select details related to animal handling, including species, type of study, test substance, procedures, and locations of designated areas

Animal Species

Include approximate number housed.

- ☐ Guinea pig
- ☐ Mouse
- ☐ Non-Human Primates (NHP)
- ☐ Rabbit
- ☐ Rat
- ☐ Other

If multi-generational, number of generations in study

Type of Study

- ☐ Behavioral
- ☐ Sensitization
- ☐ Toxicological
- ☐ Other

Test Substance

Name of Test Substance:

Purity:

Concentration:

Method of Administration

- ☐ Oral feed
- ☐ Oral gavage
- ☐ Injection
- ☐ Dermal absorption
- ☐ Aerosolization

Procedures

Check all that apply.

- ☐ Breeding
- ☐ Tail bleeds
- ☐ Oral gavage
- ☐ Cannula
- ☐ Surgery, type
- ☐ Anesthetization, method
- ☐ Euthanization, method

Location of Designated Areas

Bedding

Storage location:

Type of bedding:

Feed

Storage location:

Type of feed:

Administrative Controls, Engineering Controls, and PPE Related to Animal Handling

Administrative Controls
List any facility specific administrative controls in addition to those listed in the *Laboratory Safety Manual* and *Biological Safety Manual.*

☒Vermin control program
☐Other:

Facility Requirements
Specific facility requirements in addition to those outlined in the *Laboratory Safety Manual* and *Biological Safety Manual* (example: hands-free sink).

☒Doors are self-closing and locking.
☒Doors open inward.
☒Walls, floor, and ceilings are water resistant and designed to facilitate cleaning and housekeeping.
☒Penetrations in walls, floor, and ceilings are sealed, to include openings around ducts, doors, and door frames, to facilitate pest control and proper cleaning.
☒Ventilation is provided in accordance with the *Guide for Care and Use of Laboratory Animals*.
☒Heat and humidity is adjustable to accommodate a range of animal species.

Safety Equipment
Check each type of safety equipment available for use in the facility.

☐Biosafety cabinet ☐Not ducted ☐Ducted
☐Chemical fume hood
☐Glove box
☐Downdraft table
☐Safe needle devices
☐Cage Wash
☐Bedding station
☐Other:

Required Personal Protective Equipment (PPE)

☒Disposable or laundered lab coat
☒Disposable shoe covers
☒N95 respirator when completing bedding or cage changes
☒Disposable coveralls or laundered scrubs when completing bedding or cage changes
☒Disposable gloves (latex-free)
☒Safety glasses
☒Hair covering when completing bedding or cage changes

Additional Personal Protective Equipment (PPE)
Check each type of PPE available for use in the facility. Equipment should be inspected, cleaned, or replaced as needed.

☐Disposable sleeves
☐Utility/autoclave gloves
☐Animal-handling gloves
☐Safety goggles
☐Face shield
☐Hearing protection
☐N95 respirator
☐Other:

Appendix C
Statewide Fire Prevention Code

SFPC Table 2703.8.3.2

FLOOR LEVEL		PERCENTAGE OF THE MAQ per CONTROL AREA	NUMBER OF PERMITTED CONTROL AREAS per FLOOR	FIRE RESISTANCE RATING FOR FIRE WALLS IN HOURS
ABOVE GRADE	Higher than 9	5 %	1	2
	7-9	5 %	2	2
	4-6	12.5 %	2	2
	3	50 %	2	1
	2	75 %	3	1
	1	100 %	4	1
BELOW GRADE	1	75 %	3	1
	2	50 %	2	1
	Lower than 2	Not Allowed	Not Allowed	Not Allowed

SFPC Table 2703.1.1(1)&(2) Excerpts relevant to GMU Facility Limitations

Material	Class	STORAGE*			USE-CLOSED SYSTEM*			USE-OPEN SYSTEM	
		Solid pounds	Liquid gallons (pounds)	Gas cubic feet/NTP	Solid pounds	Liquid gallons (pounds)	Gas cubic feet/NTP	Solid pounds	Liquid gallons (pounds)
Combustible liquid	II IIIA IIIB	N/A	120 330 13200	N/A	N/A	120 330 13200	N/A	N/A	30 80 3300
Flammable gas	Gas Liquefied	N/A	N/A 30	1000 N/A	N/A	N/A 30	1000 N/A	N/A	N/A
Flammable liquids	IA IB & IC	N/A	30 120	N/A	N/A	30 120	N/A	N/A	10 30
Combination (IA, IB, IC)	N/A	N/A	120	N/A	N/A	120	N/A	N/A	30
Flammable solid	N/A	125	N/A	N/A	125	N/A	N/A	25	N/A
Organic peroxide	UD I II III IV V	1 5 50 125 No limit No limit	(1) (5) (50) (125) No limit No limit	N/A	0.25 1 50 125 No limit No limit	(0.25) (1) (50) (125) No limit No limit	N/A	0.25 1 10 25 No limit No limit	(0.25) (1) (10) (25) No limit No limit
Oxidizer	4 3 2 1	1 10 250 4000	(1) (10) (250) (4000)	N/A	0.25 2 250 4000	(0.25) (2) (250) (4000)	N/A	0.25 2 50 1000	(0.25) (2) (50) (1000)
Oxidizing gas	Gas Liquefied	N/A	N/A 15	1500 N/A	N/A	N/A 15	1500 N/A	N/A	N/A
Pyrophoric	N/A	4	(4)	50	1	(1)	10	0	0
Unstable(reactive)	4 3 2 1	1 5 50 No limit	(1) (5) (50) No limit	10 50 250 No limit	0.25 1 50 No limit	(0.25) (1) (50) No limit	2 10 250 No limit	0.25 1 10 No limit	(0.25) 1 10 No limit
Water reactive	3 2 1	5 50 No limit	(5) (50) No limit	N/A	5 50 No limit	(5) (50) No limit	N/A	1 10 No limit	(1) (10) No limit
Corrosive	N/A	5000	500	810	5000	500	810	1000	100
High Toxic	N/A	10	10	20	10	(10)	20	3	(3)
Toxic	N/A	500	(500)	810	500	(500)	810	125	(125)

*Storage is defined as material not in use.

*Use-closed system is defined as material utilized in sealed apparatuses, devices or equipment

and not exposed to the room atmosphere.
MAQ of the listed materials may be increased by 100 percent in buildings equipped throughout with an automatic sprinkler system and an additional 100% of the MAQ if the material is stored in an approved storage cabinet, gas cabinet, exhausted enclosure, or safety can.