Chemical Hygiene Plan

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Foreword

The Occupational Safety and Health Administration has published a standard titled "Occupational Exposure to Hazardous Chemicals in Laboratories", 29 CFR 1910.1450. This Laboratory Standard is designed specifically for laboratories to address the unique exposure conditions under which work is performed and to protect employees from adverse health effects that may result from their work with hazardous chemicals. The Standard requires employers to formulate and implement a comprehensive, written Chemical Hygiene Plan (CHP).

The purpose of the Chemical Hygiene Plan is to outline the procedures available to employees to protect them from the health hazards presented by the chemicals they use while working in the laboratory and to comply with all requirements of the OSHA Standard (29 CFR 1910.1450).

The two critical features of the Laboratory Standard are the requirement to appoint a Chemical Hygiene Officer (CHO), and the requirement to develop and implement a Chemical Hygiene Plan (CHP). The CHP reflects the particular character and operations of the individual laboratory situation and may be subject to revision as required by changing conditions or circumstances.

The Chemical Hygiene Officer (CHO) acts as the representative of the President of the College who has the ultimate responsibility for chemical safety in that department. The CHO also reports to the Director of Safety and Security or the Safety Officer as that person designated by the President and Dean of Student Affairs for overseeing any financial implications of the CHP and chemical safety.

This is the Chemical Hygiene Plan (CHP) developed for laboratories at Lycoming College in Williamsport, Pennsylvania. All laboratory personnel must know and follow the procedures outlined in this plan. All operations performed in the laboratory must be planned and executed in accordance with these procedures. In addition, each employee is expected to develop safe personal chemical hygiene habits aimed at the reduction of chemical exposures to themselves and coworkers.

The CHP will be accessible to all full-time employees of the laboratories designated above and any other laboratory employees, student laboratory assistants, or other interested parties. This CHP is readily available to laboratory employees in the office of the laboratory managers (Heim 212), in the office of the departmental secretary (Lynn 154), as well as in the Safety and Security Office in the lower level of Rich Hall. It will also be available on-line on the home page of the Chemistry department (http://www.lycoming.edu/chemistry/) and the home page of the Biology department (http://www.lycoming.edu/biology/).

The CHP will be reviewed at least annually and updated if necessary.

Completed Review of Chemical Hygiene Plan:

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8/10/23
Date

Table of Contents

I. Scope of Plan and Program Responsibilities 5

A. Definitions 5

a. Chief Executive Officer *5*

b. Chemical Hygiene Officer *5*

c. Safety Officer *6*

d. Laboratory Supervisors, Employees, and Workers *6*

e. Visitors *6*

f. Resources *6*

II. Standard Operating Procedures 7

A. Chemical Procurement 7

B. Chemical Handling 7

C. Chemical Storage 8

D. Laboratory Equipment 9

E. Personal Protective Equipment 9

F. Labeling 10

G. Signs 10

H. Housekeeping, Maintenance, and Inspections 11

I. Spills, Accidents, Safety Equipment, and Emergency Preparedness 11

a. Handling Spills 11

b. Handling Personal Accidents in the Laboratory 12

c. Safety and Emergency Preparedness 12

J. Recordkeeping 13

K. Chemical Waste Disposal 13

L. Safe Work Practices 14

M. Handling of Particularly Hazardous Substances 14

III. Laboratory Facilities 16

A. Control Measures 16

a. Exposure Guidelines 16

b. Fire Guidelines 16

c. Reactivity Guidelines 17

d. Corrosivity and Contact Hazard Guidelines 17

B. Engineering Controls 18

a. General Laboratory Ventilation 18

b. Chemical Fume Hoods 18
c. Glove Boxes (Class III Biosafety cabinet) 19
d. Chemical Storage Cabinets 20
IV. Employee Information 20
A. Hazard Information 20
B. Training 20
C. Medical Evaluations and Consultations 21
D. Prior Approval for Laboratory Activities 22
a. Off-Hours Work Procedures 22
b. Sole Occupancy 22
c. Hazardous Work 22
d. Unattended Operations 23
V. Appendices 23
APPENDIX A: SAFETY DATA SHEETS 24
APPENDIX B: GLOVE USES AND SELECTION 32
TABLE 1: Recommended Glove Selection for Chemicals in the Laboratory 35
APPENDIX C: GLASSWARE SAFETY 36
APPENDIX D: COMPRESSED GAS HANDLING 37
APPENDIX E: SAFE USE OF LABORATORY HEATING DEVICES 38
APPENDIX F: WORKING SAFETY WITH CRYOGENIC MATERIALS 39
APPENDIX G: CHEMICAL STORAGE LIMITS & GUIDELINES 42
TABLE 2: Examples of Common Compounds That Form Peroxides and Recommended Maximum Storage Times 47
APPENDIX H: CHEMICAL STORAGE AND CHEMICAL COMPATIBILITY 49
TABLE 3: Chemical Compatibility and Storage 50
APPENDIX I: DEPARTMENT OF CHEMISTRY, BIOCHEMISTRY AND BIOLOGY INCIDENT REPORT FORM 52
APPENDIX J: EMERGENCY ACTION PLAN 53

I. Scope of Plan and Program Responsibilities

A. Definitions

a. Chief Executive Officer

Dr. Kent Trachte, President of the College, has the ultimate responsibility for chemical hygiene throughout the laboratory and with assistance of other program administrators, will provide continued support for chemical hygiene.

b. Chemical Hygiene Officer

The Chemical Hygiene Officer is defined as a faculty member (assistant professor, associate professor, professor, or instructor) or other employee who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure. Their responsibilities are as follows:

1. Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices.

2. Act as advisor in procurement and use of chemicals in the laboratory, including determining that facilities and training levels are adequate for chemicals in use.

3. Routinely perform formal chemical hygiene and housekeeping inspections including inspections of emergency equipment.

4. Maintain current knowledge concerning the legal requirements of regulated substances in the laboratory.

5. Ensure that all records are kept as required by this manual.

6. Review and improve the Chemical Hygiene Plan on an annual basis.
   - The Chemical Hygiene Officer will conduct an annual review of all phases of the Chemical Hygiene Plan. Any recommendations for corrective actions will be provided to the department heads and the laboratory managers. Laboratory supervisors are responsible for taking corrective actions.

7. Ensure that employees and workers know the chemical hygiene requirements.

8. Determine proper level of personal protective equipment and ensure that such protective equipment is available and in working order.

9. Ensure that appropriate training has been provided to employees.

10. Monitor the chemical waste accumulation and coordinate its disposal with the laboratory manager and in conjunction with the Safety Officer. This includes the removal of chemical and biological substances that may pose a hazard prior to maintenance personnel working on furnishings, equipment, or laboratory systems.

c. Safety Officer

The Director of Safety and Security fills the role of Safety Officer. The Safety Officer has the primary responsibilities for handling medical emergency response and reviewing all aspects of safe work practices for the laboratory.

d. Laboratory Supervisors, Employees, and Workers

Laboratory supervisors include all faculty members and laboratory instructors. Laboratory employees include the chemical hygiene officer and the laboratory manager. Laboratory workers include teaching assistants, research assistants, laboratory assistants, and students.

Their responsibilities are as follows:

1. Planning and conducting each laboratory operation in accordance with the Chemical Hygiene Plan

2. Developing good personal chemical hygiene habits

3. Laboratory supervisors are, in general, responsible for ensuring laboratory safety

e. Visitors

A visitor is classified as anyone who is not a laboratory supervisor, employee, or worker. All visitors must have access to read and understand the Chemical Hygiene Plan.

f. Resources

1. Copies of the Chemical Hygiene Plan are in the following areas:
   - Office of the Laboratory Managers (Heim 212)
   - Office of the Departmental Secretary (Lynn 154)
   - Safety and Security Office (Lower Level- Rich Hall)
   - Lycoming College website: (http://www.lycoming.edu/chemistry/) and (http://www.lycoming.edu/biology/)

2. Chemical inventory and copies of Safety Data Sheets (SDS) for each chemical are in the laboratory manager's office and can also be found online.

3. Phone numbers for notifying the proper authorities in the event of an emergency or accident:
   - Lycoming College Safety and Security (x4911)
   - Williamsport City Police (570-327-7560)
   - UPMC Susquehanna Emergency Room Williamsport (570-321-1000)
   - Poison Control Center/Williamsport Hospital (570-321-1000)
   - County of Lycoming Department of Public Safety (570-433-4461)
   - Department of Environmental Protection (570-327-3636)

4. See Appendix J for additional Emergency Preparedness Resources.

II. Standard Operating Procedures

A. Chemical Procurement

a. The decision to procure a chemical shall be a commitment to handle and use the chemical properly from initial receipt to ultimate disposal.

b. Before a new chemical is ordered, the requestor must determine the known potential hazards (e.g., toxicity, flammability, and reactivity), proper handling, storage, and disposal of the chemical.

c. All chemicals should be purchased in shatter resistant, plastic, or plastic-coated containers whenever possible.

d. The smallest working quantity of chemical should be purchased.

e. Personnel initiating the request shall notify the laboratory manager of the request to ensure the proper chemical storage and handling of the chemical.

f. Personnel initiating the request shall be knowledgeable of the proper procedures for receipt and shall be responsible for the proper disposition of the chemical.

g. Chemical containers shall not be accepted without accompanying labels and proper packaging in accordance with all appropriate regulations.

h. An SDS will be obtained for all chemicals procured.

i. All chemical containers shall be initialed and dated when received and when opened.

j. Personnel initiating the chemical request shall notify the laboratory manager, so it is properly entered into the departmental chemical database following the proper procedures. When it is consumed or disposed of, it shall be removed from the chemical database.

B. Chemical Handling

Each laboratory employee with the training, education, and resources provided by supervision, shall develop and implement work habits consistent with this CHP to minimize person and co-worker exposure to the chemicals in the laboratory. Based on the realization that all chemicals inherently present hazards in certain conditions, exposure to all chemicals shall be minimized. General precautions which shall be followed for the handling and use of all chemicals are:

a. Skin contact with all chemicals shall be avoided or minimized; wash promptly if skin contact is made with any chemical, regardless of corrosivity.

b. All employees shall wash their hands prior to leaving the laboratory.

c. Mouth suction for pipetting or starting a siphon is prohibited.

d. Bringing food or beverages into the laboratory is prohibited; eating, drinking, smoking, using tobacco, chewing gum, or application of cosmetics in areas where laboratory

chemicals are present shall be avoided. Hands shall be thoroughly washed prior to exiting the laboratory and performing these activities.

e. Storage, handling, and consumption of food or beverages shall not occur in storage areas where refrigerators, glassware, or utensils are used for laboratory operations. Each storage area shall be labeled with "NO FOOD STORAGE" or "FOOD STORAGE ONLY" to eliminate confusion.

f. Risk determinations shall be conservative in nature.

g. Any chemical mixture shall be assumed to be as toxic as or even more toxic than its most toxic component.

h. Substances of unknown toxicity shall be assumed to be toxic.

i. Laboratory employees shall be familiar with the symptoms of exposure for the chemicals with which they work and the precautions necessary to prevent exposure.

j. In all cases chemical exposure, neither the Permissible Exposure Limits (PELs) of OSHA nor the Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH) shall be exceeded. If the PEL or the TLV is not available for a given substance, the substance will be assumed to be toxic and must be used in a fume hood.

k. Specific precautions based on the toxicological characteristics of individual chemicals shall be implemented as deemed necessary by the chemical hygiene officer. These special precautions are listed in *Section II.M – Handling of Particularly Hazardous Substances*.

C. Chemical Storage

a. Received chemicals shall be immediately moved to the designated storage area. Glass containers of 2L or greater capacity shall be placed in carrying containers or shipping containers during transport. Use of a cart and elevator to transport containers between floors is highly recommended. Highly reactive chemicals, regardless of size, should be similarly transported.

b. The storage area shall be well-illuminated, with all storage maintained in such a way that it can be seen. Containers of greater than 4L capacity for liquids shall be stored no more than two feet from ground level (Bottom shelf where possible).

c. Chemicals shall be segregated by hazard classification and compatibility in a well-identified area, with local exhaust ventilation. Chemicals should be properly stored in the Flammable, Oxidizer, or General Chemical Storage rooms on the ground level of the Heim Biology and Chemistry Building. See Appendix H for chemical compatibility.

d. The long-term storage area shall not be used primarily as a preparation or repackaging area.

e. The storage area shall be accessible during normal working hours. Access to the storage area will be only with permission of one of the faculty members, laboratory manager, or chemical hygiene officer.

f. When chemicals are removed from the storage area, they shall be placed in an outside container or bucket. When more than one container of chemicals is transported from the downstairs storage room, a cart and/or carrying container shall be used. Elevators shall be utilized to transport chemicals between floors.

g. Storage of chemicals at the lab bench or other work areas shall be minimized. The container size shall be the minimum convenient. The amounts of chemicals at the laboratory bench shall be as small as practical. Care must be taken that sensitive chemicals are not stored in sunlight or exposed to heat.

h. Stored chemicals shall be examined at least annually under the direction of the chemical hygiene officer or laboratory manager for container integrity. The inspection should determine whether any corrosion, deterioration, or damage has occurred to the container or to the storage facility as a result of leaking chemicals.

i. Periodic inventories of chemicals outside the storage area shall be conducted by the supervisor of the area involved. Unneeded items shall be properly discarded or returned to the storage area.

D. Laboratory Equipment

a. All laboratory equipment shall only be used for its intended purpose.

b. All glassware will be handled and stored with care to minimize breakage; all broken glassware will be immediately disposed of in the broken glass container.

c. All permanently evacuated glass apparatus (e.g., Dewar flasks) shall be shielded and/or taped to contain chemicals and glass fragments should implosion occur.

d. Labels shall be attached to all chemical containers, identifying the contents and related hazards. Refer to Section II.F.

e. Hazardous waste and non-hazardous waste receptacles shall be identified as such.

f. All laboratory equipment shall be inspected on a periodic basis and replaced or repaired as necessary.

E. Personal Protective Equipment

a. Eye Protection is required for all persons, including visitors, entering a laboratory, at any time. Safety glasses must be equipped with permanently attached side shields. In the Chemistry department, safety glasses meeting ANSI/ISEA Z87.1 are required.

b. Additional face protection (face shield, goggles, etc.) may be required based on the procedures being conducted. Examples of procedures which may need additional protection include the pouring of caustic chemicals or solutions or acid, spray decontamination operations, etc.

c. No open-toed shoes or sandals will be worn in laboratories. Footwear that does not cover the tops of the toes and foot, sides of the foot and back of the foot / heel area and allows these areas to be exposed are NOT acceptable.

d. Wear appropriate gloves whenever the potential for skin contact with corrosive or toxic materials, rough or sharp- edged objects, very hot or cold materials, or chemicals of unknown toxicity exists. Select gloves based on the substance being handled, the particular hazard involved, and their suitability for the operation being conducted. Inspect gloves before each use and replace gloves that show signs of wear (i.e., cracking, loss of elasticity, etc.). Never reuse disposable gloves. See Appendix B for proper glove selection.

F. Labeling

a. All containers in the laboratory shall be labeled. This includes chemical containers and waste containers. The label shall be informative and durable, and the container must be clearly marked with accumulation date or date of acquisition or preparation, indication of hazard, and the label must accurately identify contents.

b. Portable containers shall be labeled by the individual using the container. These labels must, at minimum, the identity of the contents and any important hazard information in case of spillage during transport.

c. Exceptions for labeling requirements shall be made for chemical transfer from a labeled container into a container which is intended only for the immediate use by the person who performed the transfer.

d. The labeling program shall be periodically inspected by the laboratory supervisor, the laboratory manager, and/or the chemical hygiene officer.

G. Signs

Signs are used to communicate the presence of potential hazards, protective requirements, and/or other relevant safety information. It is important to read signs in the workplace and to communicate hazards to others using the required signs. Prominent signs and labels of the following types should be posted:

a. Emergency telephone numbers of emergency personnel/facilities, faculty, laboratory supervisors, the laboratory manager, and the chemical hygiene officer.

b. Location signs for safety showers, eyewash stations, first aid equipment, fire extinguishers, fire blankets, exits, and areas where food and beverage consumption and storage are NOT permitted.

c. Warnings at areas or equipment where special or unusual hazards exist.

H. Housekeeping, Maintenance, and Inspections

Each laboratory worker is directly responsible for the cleanliness of his or her workspace, and jointly responsible for common areas of the laboratory. Laboratory management shall insist on the maintenance of the following housekeeping standards:

a. All spills on laboratory benches or floors should be immediately cleaned and properly disposed of.

b. The lab benches shall be kept clear of equipment and chemicals except those necessary for the work currently being performed.

c. All equipment should be unplugged when not in use.

d. The work area shall be cleaned at the end of each operation.

e. All apparatus shall be thoroughly cleaned and returned to storage upon completion of usage.

f. All floors, aisles, exits, fire extinguishing equipment, emergency wash stations, and emergency disconnects, and other emergency equipment shall remain unobstructed.

g. All labels shall face front.

h. Chemical containers shall be clean, properly labeled and returned to storage upon completion of usage.

i. All chemical waste will be disposed of in accordance with prudent waste disposal procedure.

j. Floors should be cleaned regularly. Stairways and hallways should not be used as storage areas. Access to exits, emergency equipment, and utility controls should never be blocked.

I. Spills, Accidents, Safety Equipment, and Emergency Preparedness

a. *Handling Spills*

1. The small quantities of chemicals used in the academic laboratories should preclude the possibility of what could be classed as a major spill in the laboratory. Laboratory supervisors should make sure materials to neutralize spills are on hand before an experiment starts.

2. In case of a spill, the problem should be resolved immediately by means of appropriate treatment. This includes neutralization of acids or bases, mercury spill kits, absorption of organic liquids in some inert absorbent material such as vermiculite, etc. In all cases, waste generated by a spill shall be collected and disposed of in a proper manner, and the area properly cleaned and, if necessary, ventilated.

b. *Handling Personal Accidents in the Laboratory*

1. All injuries incurred in the laboratory, no matter how seemingly minor, must be reported to the laboratory supervisor in charge for immediate attention and written records must be kept of all such injuries.

2. All incidents, regardless of severity, must be reported using the Lycoming College Departments of Chemistry, Biochemistry and Biology Incident Report Form and turned in to the chemical hygiene officer. A copy of the form can be found in Appendix I.

3. In case of a minor cut or burn, immediate first aid may be given with supplies in the first aid cabinet, but the injured person should then report as soon as it is practicable to Lycoming College Health Services.

4. In cases of real emergency, or during hours when Health Services is not open, call the Department of Safety and Security (x4911). If it seems necessary for immediate action, call an ambulance directly through 911.

5. All local emergency contact numbers can be found in *Section I.f.3*.

c. *Safety and Emergency Preparedness*

The following procedures are required to adequately prepare for workplace emergencies:

1. Identify the types of emergencies which could occur in your laboratory. At a minimum the list must include fires, chemical spills, medical and security emergencies, and natural disasters, equipment specific, and utility interruptions. The list may also include explosions and other appropriate events. (See Appendix J for Emergency Action Plan)

2. Telephone numbers of emergency personnel, supervisors, and other workers as deemed appropriate have been posted.

3. All laboratory personnel will be trained in the proper use of fire extinguishers when hired and as needed thereafter. Fire extinguishers shall be inspected monthly and records kept.

4. All employees who might be exposed to chemical splashes shall be instructed in the location and proper usage of the emergency eyewash station and emergency safety showers. All emergency eyewash stations shall be tested weekly. Emergency safety showers shall be tested routinely. These inspections shall be performed and verified by a laboratory supervisor. Records shall be maintained.

5. Location signs for safety and emergency equipment have been posted.

6. All laboratory supervisors, employees, workers, and visitors shall be trained in the emergency evacuation plan. The emergency evacuation plan shall be posted throughout the building and be always visible.

J. Recordkeeping

a. Accident investigations will be conducted by the immediate laboratory supervisor with assistance from other personnel as deemed necessary.

b. Accident reports will be written and retained for ten years.

c. Medical records for employees exposed to hazardous chemicals and harmful physical agents will be maintained for the duration of employment plus 30 years per 29 CFR 1910.20.

d. Inventory and usage records for high-risk substances (amounts of substances on-hand, amounts used, and name of workers involved) shall be maintained for ten years.

e. Records of inspections of equipment will be maintained for five years.

f. Records of employee training will be maintained for ten years.

K. Chemical Waste Disposal

The purpose of a waste disposal program is to ensure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals and wastewater. Proper waste disposal is important to the safety of other employees whose job it is to handle the waste. Each employee is responsible for properly preparing waste for disposal and for following the procedures in the manual.

The accumulation of waste in this department is of such a small quantity as to put Lycoming College well below the level of a small quantity waste generator classification. Nevertheless, it is expected that extra care will be exercised to ensure the proper collection and disposition of any hazardous waste.

a. Disposal of all chemical waste will be carried out under the direction and/or supervision of the chemical hygiene officer, the laboratory manager, and in conjunction with the Safety Officer.

b. The laboratory supervisors shall ensure proper collection (for disposal) of wastes generated in their laboratories.

c. Solid chemical waste should not be discarded into waste baskets, but rather disposed of in a permissible way.

d. Any accidental mercury spills (i.e., from broken thermometers, etc.) will immediately be cleaned up with a mercury spill kit by a faculty member, the laboratory supervisor, a laboratory employee, and/or the laboratory manager. No other laboratory worker shall attempt mercury cleanup.

L. Safe Work Practices

a. Laboratory supervision must ensure that each laboratory worker knows and follows the rules and procedures established in this plan.

b. Working alone, working after hours, or unattended laboratory operations are NOT permitted, except as described in *Section IV.D – Prior Approval for Laboratory Activities*.

c. All employees shall remain vigilant to unsafe practices and conditions in the laboratory and shall immediately report such practices and/or conditions to the laboratory supervisor. The laboratory supervisor must correct unsafe practices and/or conditions promptly.

d. Long hair and loose-fitting clothing shall be confined close to the body when appropriate (working with open flames, centrifuges, operating instruments, etc.)

e. Use only those chemicals appropriate for the ventilation system.

f. Avoid unnecessary exposure to all chemicals by any route.

g. Do not taste any chemicals. In general, avoid smelling chemicals except as directed.

h. Encourage safe work practices in coworkers by setting the proper example.

i. Horseplay is strictly forbidden.

j. Be aware of current SDS information concerning the chemicals you are working with and plan operations, equipment, and protective measures accordingly.

k. Know the location and proper use of emergency equipment, and use engineering controls in accordance with *Section III.B*.

l. Inspect personal protective equipment prior to use and wear appropriate protective equipment as procedures dictate and when necessary to avoid exposure.

M. Handling of Particularly Hazardous Substances

When laboratory procedures require the use of additional classifications of chemicals (defined in the appropriate SDS as allergens, embryotoxins, teratogens, reproductive toxins, "select carcinogens", and others with a high degree of acute toxicity), additional special precautions shall be implemented as deemed necessary by the chemical hygiene officer.

In general, for each of these categories it is expected that the hazardous chemicals will only be used where absolutely necessary (i.e., no safer, equally suitable alternative exists) and that the amounts used will be the minimum required. In addition, the following practices are recommended while handling substances with a high degree of toxicity:

a. *Establishment of a Designated Area*
The entire laboratory, a specific area, or a containment device within the laboratory is to be designated and labeled with appropriate signage.

b. *Use of Containment Devices*
Use of containment devices, such as fume hoods or glove boxes, in certain circumstances. Examples of such circumstances include:

1. The use of volatile substances

2. Manipulation that may result in the generation of aerosols

3. Any manipulations, handling, or reaction that may result in the uncontrollable release of the particularly hazardous substance

c. *Safe Removal of Contaminated Waste*
Collect contaminated waste for disposal in containers separate from normal laboratory waste. Each waste container shall be properly labeled to identify the contents.

d. *Implementation of Decontamination Procedures*
Implement laboratory and/or substance specific decontamination procedures at the conclusion of a particular task or at the end of the workday. Take extra precautions to maintain good personal hygiene and to thoroughly wash/decontaminate prior to leaving the designated area.

e. *Working with Allergens and Embryotoxins*
1. Suitable gloves to prevent hand contact shall be worn when exposed to allergens or substances of unknown allergen activity.

2. Women of child-bearing age will handle embryotoxins only in a hood with confirmed satisfactory performance and will use personal protective equipment to prevent skin contact as prescribed by the laboratory supervisor and chemical hygiene officer.

   Any woman may opt-out of using embryotoxins at any time without punishment or retaliation.

3. Embryotoxins will be stored in adequately ventilated areas in unbreakable secondary containers.

4. The laboratory supervisor and chemical hygiene officer will be notified of spills and other exposure incidents immediately.

5. A physician will be consulted when appropriate.

f. *Working with Chemicals of Moderate or High Acute Toxicity*
1. Areas where these chemicals are stored and used are of restricted access and have special warning signs posted.

2. A special hood with a minimum face velocity of 75 linear feet/minute or other containment device will be used (*Section III.B. – Engineering Controls*).

3. Gloves and long-sleeved shirts will be used. Hands and arms will be washed immediately after working with these chemicals.

4. Two people will always be present during work with these chemicals.

g. *Working with Chemicals of High Chronic Toxicity*

1. All transfer and work with these substances shall be in a designated area: a restricted access hood, glove box, or portion of the lab.

2. Approval of the laboratory supervisor will be obtained before use.

3. Vacuum pumps must have scrubbers, oil-mist filters, charcoal filters, or high-efficiency particulate arrestor (HEPA) filters.

4. Any contaminated equipment or glassware will be decontaminated in the hood before removal from the designated area.

5. For powders, a wet mop or vacuum with a HEPA filter will be used for cleanup.

6. The designated area will be marked with warning and restricted access signs.

7. Containers will be stored in a ventilated, limited access area in labeled, unbreakable, chemically resistant, secondary containers.

III. Laboratory Facilities

A. Control Measures

In this section the criteria are presented for which the use of engineered controls and/or personal protective equipment are to be used.

a. *Exposure Guidelines*

1. Most materials have some guidelines for exposure. (e.g., Threshold Limit Values (TLVs) or Permissible Exposure Limits (PELs) When such a value exists, the limits will be used by the immediate supervisor to determine proper safety precautions, including control measures and safety personal protective equipment.

2. When TLV or PEL values exist and are low (50ppm or less) the user of the chemical must use it in an operating fume hood. If TLV or PEL values are not available for that substance, the substance will be assumed to be toxic and must also be used in a fume hood.

3. If the chemical has a high vapor pressure (50mmHg or higher at 20°C) it must be used in a well-ventilated area.

b. *Fire Guidelines*

1. The flammability of a chemical is generally determined by its flash point. (i.e., the lowest temperature at which an ignition source can cause the chemical to ignite momentarily)

2. The flash point will be used as the reference for "fire hazard" at Lycoming College. OSHA and NFPA have guidelines on when a chemical is considered flammable. Those guidelines are herein adopted for use in the laboratory.

    - "Flammable" will be used to refer to chemicals with a flash point of $\leq$100°F or 38.7°C. Such chemicals MUST be stored in a designated flammable storage area or cabinet.

    - Chemicals with flash points above 100°F or 38.7°C are called "combustible". Such chemicals must be stored away from any source of ignition.

3. More detailed discussions on fire hazards can be found in OSHA standard (29 CFR 1910) and the local fire code.

c. *Reactivity Guidelines*

1. NFPA has guidelines regarding "reactive" chemicals however these are centered on a fire emergency. Other guidelines regarding reactive chemicals can be found in the following references:

    - "Handbook of Reactive Chemical Hazards", 3rd edition, L. Bretherick; Butterworths, 1985.
    - Regulations of Department of Transportation (DOT) (49 DFR)
    - Environmental Protection Agency (40 CFR)

2. At Lycoming College, a reactive chemical is one which is:
    - Ranked by the NFPA as 3 or 4 reactivity

    - Identified by any of the references in *Section III.A.c.1.*, or known to be:
        - An oxidizer
        - An organic peroxide
        - An explosive
        - Unstable or subject to polymerization
        - Reactive with ordinary substances

    - Once a chemical has been determined to be reactive, all proper safety precautions will be used, including extra segregation in storage and prohibition on mixing with other chemicals without appropriate personal protective equipment and precautions.

d. *Corrosivity and Contact Hazard Guidelines*

1. A corrosive chemical is defined by OSHA (29 CFR) as a chemical that causes visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact. Lycoming College will consider a chemical corrosive if it fits this definition or if it has a very high ($\geq$ 11) or a very low ($\leq$ 3) pH.

2. A skin or eye contact hazard chemical is one where the chemical's route of entry for its toxic effects is through the skin or eyes. Chemicals which are contact hazards will be determined by examining the medical and industrial hygiene literature.

3. Corrosive or contact-hazard chemicals should be handled only when wearing suitable personal protective equipment including suitable eye protection and chemical-resistant gloves.

B. Engineering Controls

Chemical safety is accomplished by awareness of the chemical hazards and by eliminating or reducing the potential for exposure through a variety of controls. When substitution of a less hazardous chemical is not practical, engineering controls are the preferred method of reducing potential employee exposures.

Engineering controls include the use of laboratory fume hoods, glove boxes, ventilated weigh booths, and other specific local exhaust ventilation such as ventilated equipment enclosures, elephant trunks/articulating arms, back draft and down draft tables. If engineering controls are not feasible, or as an added degree of precaution, potential employee exposures may be reduced using personal protective equipment. Some engineering measures are outlined below:

a. *General Laboratory Ventilation*

General ventilation is intended primarily to increase the comfort of laboratory workers and to provide a supply of air that will be exhausted through general exhaust and a variety of auxiliary local ventilation devices (hoods, vented canopies, vented storage cabinets, etc.). Laboratory air is exhausted outdoors and not recycled. As a general rule, the air pressure in a laboratory is negative with respect to the rest of the building.

b. *Chemical Fume Hoods*

A local exhaust ventilation system that prevents contaminants from entering general room ventilation. The hood usually consists of a lab bench surrounded on three sides with solid partitions and, on the fourth, with adjustable sashes. Fume hoods are used for laboratory scale handling of solvents and chemicals. Chemical fume hoods are not intended to be used for potent compound handling, evaporation of chemicals, nor storage.

A. The following procedures shall apply to the use of local exhaust ventilation and laboratory hoods:

1. Openings of local exhaust ventilation shall be placed as close as possible to sources of the air contaminant.

2. The window on the face of the hood shall be clear prior to usage.

3. Hood fans shall operate when hoods are being used.

4. After using the hoods, operate the fan for an additional period of time sufficient to clear residual contaminants from the ductwork.

5. The laboratory hoods shall be utilized for all chemical procedures which might result in the release of hazardous chemical vapors or dust. As a general rule, the hood shall be used for all chemical procedures involving substances which are especially volatile and have a permissible exposure limit (PEL) of less than 50ppm.

B. The following work practices shall apply to the use of hoods:

1. Confirm adequate hood ventilation performance prior to opening chemical containers inside the hood. An inward flow of air can be confirmed by holding a piece of paper at the face of the hood and observing the movement of the paper.

2. Keep the sash of the hood closed at all times except when adjustments within the hood are being made. At these times, maintain the sash height as low as possible.

3. Storage of chemicals and equipment inside the hood shall be kept to a minimum.

4. Minimize interference with the inward flow of air into the hood.

5. Leave the hood operating when it is not in active use if hazardous chemicals are contained inside the hood or if it is uncertain whether adequate general laboratory ventilation will be maintained when the hood is non-operational.

6. The ventilation system shall be inspected annually. The hood face velocity shall be maintained between 75-125 feet/minute.

7. The fume hoods should be certified at least every ten years. Fume hoods that are heavily utilized with volatile substances or substances with a PEL < 50 ppm should be certified every three years. A record of each inspection shall be maintained in the laboratory manager's office.

c. *Glove Boxes (Class III Biosafety cabinet)*
A gas-tight local exhaust ventilation system that prevents contaminants from entering general room ventilation. The glove box usually consists of a totally enclosed gas-tight box equipped with impermeable gloves to allow for manipulation. Access to the interior of the box is through a pass-through hatch. Negative pressure gloves boxes or isolators are typically used for handling potent compounds.

1. Limitations of a glove box are based on exhaust ventilation design (i.e., Positive pressure glove boxes) and are permitted for use with substances of known high chronic or acute toxicity.

2. Prior to use, employees should inspect the glove box to ensure that the certification sticker is present and that the glove box has been recently inspected.

3. Inspect glove boxes before each use to ensure the box is providing the appropriate pressure (i.e., negative air pressure for potent compounds and positive for environmental control) according to manufacturer's specifications and to ensure glove integrity. For a negative pressure glove box, ventilation rate must be at least two volume changes/hour and pressure at least 0.5 inches of water.

d. *Chemical Storage Cabinets*

1. Storage cabinets for flammable and hazardous chemicals will be ventilated as needed.

2. Store flammable chemicals in Underwriters Laboratories (UL) and Factory Mutual (FM) approved cabinets.

3. Do not store incompatible materials together. Avoid overloading the cabinet and avoid storing paper or cardboard inside the cabinets.

4. Store corrosive chemicals in dedicated cabinets. Separate acids from bases by distance or barriers.

5. Reference **Appendix H** for chemical compatibility guidelines when storing chemicals.

e. *Modification*
No modification of engineering controls will occur unless testing indicates that worker protection is found to be inadequate.

f. *Improper Function*
Improper function of engineering controls must be reported to the chemical hygiene officer immediately. The system shall be taken out of service until proper repairs have been carried out.

g. *Usage*
All employees shall follow proper work practices when using the engineering controls.

IV. Employee Information

A. Hazard Information
All employees will be apprised of the hazards presented by the chemicals in use in the laboratory. Each employee shall receive training at the time of initial assignment to the laboratory, prior to assignments involving new exposure situations, and at a regular frequency as determined by his/her immediate laboratory supervisor.

B. Training
The training shall include methods of detecting the presence of a hazardous chemical, physical and health hazards of chemicals in the lab, and measures employees should take to protect themselves from these hazards. The training, which shall be conducted by each department and/or the immediate supervisor of the employee, shall present the details of the Chemical Hygiene Plan, and shall include:

a. The contents of the OSHA laboratory standard and its appendices (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106)

b. The location and availability of the Chemical Hygiene Plan

c. The permissible exposure limits for OSHA regulated substances or recommended exposure values for other hazardous chemicals not regulated by OSHA which are present in the laboratory

d. Location and availability of reference material on chemical hygiene

e. Location and use of Safety Data Sheets (SDS) (See Appendix A)

C. Medical Evaluations and Consultations

a. Laboratory employees who work with hazardous chemicals shall be given an opportunity to receive medical attention, including any follow-up examination that the examining physician determines to be necessary, under the following circumstances:

1. Whenever an employee develops signs or symptoms associated with exposure to a hazardous chemical in the laboratory, the employee shall be provided with an opportunity to receive an appropriate medical examination.

2. Whenever an event takes place in the work area such as a spill, leak, explosion, or other occurrence resulting in the likelihood of hazardous exposure, the affected employee shall be provided an opportunity to receive a medical consultation. The consultation is provided to determine the need for a medical examination.

3. Where industrial hygiene exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the permissible exposure limit for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements) the affected employee shall receive preventative medical testing as part of a comprehensive medical surveillance program.

b. All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

c. The following information shall be provided to the licensed physician by the laboratory supervisor, chemical hygiene officer, or employee:

1. The identity of the hazardous chemical(s) to which the employee may have been exposed

2. A description of the conditions under which the exposure occurred, including quantitative exposure monitoring data, if available

3. A description of the signs and symptoms of exposure that the employee is experiencing, if any

d. For medical examinations or consultations required under the Laboratory Standard, the examining physician shall give his/her written opinion to the appropriate site personnel.

Physician's opinion shall include:

1. Any recommendation for further medical follow-up

2. The results of the medical examination and any associated tests

3. Any medical condition that may be revealed during the examination that may place the employee at an increased risk as a result of exposure to a hazardous chemical found in the workplace

4. A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment

5. The written opinion shall not reveal specific findings regarding diagnoses unrelated to occupational exposure

D. Prior Approval for Laboratory Activities

Certain laboratory activities present specific, foreseeable hazards. These activities include off-hours work, sole occupancy of building, hazardous operations, and unattended operations. Written prior approval must be obtained from the laboratory supervisor prior to the performance of these activities.

a. *Off-Hours Work Procedures*

Laboratory workers are not permitted to work after hours in the laboratory, except as specifically authorized by the laboratory supervisor.

b. *Sole Occupancy*

1. Laboratory work should not be performed by laboratory workers when they are the only person in the building. Persons needing to work alone after hours are required to have the permission of their laboratory supervisor and should bring a "buddy" who is:
   - An adult
   - Is nearby (on the same floor) in the building
   - Is aware that they are working and agrees to check on them periodically

2. Laboratory supervisors and laboratory employees are permitted to perform routine laboratory work in the building; however, they should ensure that their presence and approximate duration of stay in the building are known to someone and should attempt to minimize laboratory work alone.

c. *Hazardous Work*

1. All hazardous operations are to be performed during a time when at least two personnel are present in the laboratory.

2. At no time shall a laboratory person, while working alone in the laboratory, perform work which is considered hazardous.

3. The determination of hazardous operations shall be made by the laboratory supervisor.

d. *Unattended Operations*
When laboratory operations are performed which will be unattended by laboratory personnel (continuous operations, overnight reaction, etc.) the following procedures will be employed:

1. The laboratory supervisor will determine whether the unattended operation will be permitted.

2. The laboratory supervisor will review work procedures to ensure the safe completion of the operation.

3. An appropriate sign will be posted at all entrances to the laboratory.

4. The overhead or hood lights in the laboratory will be left on if the operation permits.

5. Precautions shall be made for the interruption of utility service during the unattended operation. (Loss of water pressure, electricity, gas shutoff, etc.).

6. The person responsible for the operation will return to the laboratory at the conclusion of the operation to dismantle the apparatus.

V. Appendices

APPENDIX A: SAFETY DATA SHEETS

Safety Data Sheets (SDS) are an important requirement of the OSHA Hazard Communication Standard. SDS have become important documents to inform employees, students, and the general public about how materials can be safely handled, used, and stored.

A. *Employer Responsibilities*

Employers must ensure that the SDSs are readily accessible to employees for all hazardous chemicals in their workplace. This may be done in many ways. For example, employers may keep the SDSs in a binder or on computers if the employees have immediate access to the information without leaving their work area when needed and a back-up is available for rapid access to the SDSs in the case of a power outage or other emergency. Furthermore, employers may want to designate a person(s) responsible for obtaining and maintaining the SDSs. If the employer does not have an SDS, the employer or designated person(s) should contact the manufacturer to obtain one.

B. *Safety Data Sheets*

The Hazard Communication Standard (HCS) (29 CFR 1910.1200(g)), revised in 2012, requires that the chemical manufacturer, distributor, or importer provide Safety Data Sheets (SDSs) (formerly MSDSs or Material Safety Data Sheets) for each hazardous chemical to downstream users to communicate information on these hazards. The information contained in the SDS is largely the same as the MSDS, except now the SDSs are required to be presented in a consistent user-friendly, 16-section format. The following provides guidance to help workers who handle hazardous chemicals to become familiar with the format and understand the contents of the SDSs.

A description of all 16 sections of the SDS, along with their contents, is presented below:

1. Identification

This section identifies the chemical on the SDS as well as the recommended uses. It also provides the essential contact information of the supplier. The required information consists of:

a. Product identifier used on the label and any other common names or synonyms by which the substance is known.

b. Name, address, and phone number of the manufacturer, importer, or other responsible party, and emergency phone number.

c. Recommended use of the chemical (e.g., a brief description of what it does, such as flame retardant) and any restrictions on use (including recommendations given by the supplier).

2. Hazard Identification

This section identifies the hazards of the chemical presented on the SDS and the appropriate warning information associated with those hazards. The required information consists of:

a. The hazard classification of the chemical (e.g., flammable liquid, corrosive, etc.)

b. Signal word

c. Hazard statement(s)

d. Pictograms (the pictograms or hazard symbols may be presented as graphical reproductions of the symbols in black and white or be a description of the name of the symbol (e.g., skull and crossbones = toxic, flame = flammable)

e. Precautionary statement(s)

f. Description of any hazards not otherwise classified

g. For a mixture that contains an ingredient(s) with unknown toxicity, a statement describing how much (percentage) of the mixture consists of ingredient(s) with unknown acute toxicity. Please note that this is a total percentage of the mixture and not tied to the individual ingredient(s).

3. Composition and Information on Ingredients

This section identifies the ingredient(s) contained in the product indicated on the SDS, including impurities and stabilizing additives. This section includes information on substances, mixtures, and all chemicals where a trade secret is claimed. The required information consists of:

a. *Substances*
   - Chemical name
   - Common name and synonyms
   - Chemical Abstracts Service (CAS) number and other unique identifiers
   - Impurities and stabilizing additives, which are themselves classified and which contribute to the classification of the chemical

b. *Mixtures*
   - Same information required for substances
   - The chemical name and concentration (i.e., exact percentage) of all ingredients which are classified as health hazards and are:
     - Present above their cut-off/concentration limits
     - Present a health risk below the cut-off/concentration limits
   - The concentration (exact percentages) of each ingredient must be specified except concentration ranges may be used in the following situations:
     - A trade secret claim is made
     - There is batch-to-batch variation
     - The SDS is used for a group of substantially similar mixtures

c. *Chemicals where a trade secret is claimed*

A statement that the specific chemical identity and/or exact percentage (concentration) of composition has been withheld as a trade secret is required.

4. First Aid Measures

This section describes the initial care that should be given by untrained responders to an individual who has been exposed to the chemical. The required information consists of:

a. Necessary first-aid instructions by relevant routes of exposure (inhalation, skin and eye contact, and ingestion)

b. Description of the most important symptoms or effects, and any symptoms that are acute or delayed

c. Recommendations for immediate medical care and special treatment needed, when necessary

5. Fire-Fighting Measures
This section provides recommendations for fighting a fire caused by the chemical. The required information consists of:

a. Recommendations of suitable extinguishing equipment, and information about extinguishing equipment that is not appropriate for a particular situation

b. Advice on specific hazards that develop from the chemical during the fire, such as any hazardous combustion products created when the chemical burns

c. Recommendations on special protective equipment or precautions for firefighters

6. Accidental Release Measures
This section provides recommendations on the appropriate response to spills, leaks, or releases, including containment and cleanup practices to prevent or minimize exposure to people, properties, or the environment. It may also include recommendations distinguishing between responses for large and small spills where the spill volume has a significant impact on the hazard. The required information may consist of recommendations for:

a. Use of personal precautions (such as removal of ignition sources or providing sufficient ventilation) and protection equipment to prevent the contamination of skin, eyes, and clothing

b. Emergency procedures, including instructions for evacuations, consulting experts when needed, and appropriate protective clothing

c. Methods and materials used for containment (e.g., covering the drains and capping procedures)

d. Cleanup procedures (e.g., appropriate techniques for neutralization, decontamination, cleaning or vacuuming; absorbent materials; and/or equipment required for containment/cleanup)

7. Handling and Storage
This section provides guidance on the safe handling practices and conditions for safe storage of chemicals. The required information consists of:

a. Precautions for safe handling, including recommendations for handling incompatible chemicals, minimizing the release of the chemical into the environment, and providing advice on general hygiene practices (e.g., eating, drinking, and smoking in work areas is prohibited)

b. Recommendations on the conditions for safe storage, including any incompatibilities. Provide advice on specific storage requirements (e.g., ventilation requirements)

8. Exposure Controls and Personal Protection

This section indicates the exposure limits, engineering controls, and personal protective measures that can be used to minimize worker exposure. The required information consists of:

a. OSHA Permissible Exposure Limits (PELs), American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the safety data sheet, where available.

b. Appropriate engineering controls (e.g., use local exhaust ventilation, or use only in an enclosed system)

c. Recommendations for personal protective measures to prevent illness or injury from exposure to chemicals, such as personal protective equipment (PPE) (e.g., appropriate types of eye, face, skin or respiratory protection needed based on hazards and potential exposure)

d. Any special requirements for PPE, protective clothing or respirators (e.g., type of glove material, such as PVC or nitrile rubber gloves; and breakthrough time of the glove material)

9. Physical and Chemical Properties

This section identifies physical and chemical properties associated with the substance or mixture. The minimum required information consists of:

a. Appearance (physical state, color, etc.)
b. Upper/lower flammability or explosive limits
c. Odor
d. Vapor pressure
e. Odor threshold
f. Vapor density
g. pH
h. Relative density
i. Melting point/freezing point
j. Solubility(ies)
k. Initial boiling point and boiling range
l. Flash point
m. Evaporation rate
n. Flammability (solid, gas)
o. Partition coefficient: n-octanol/water (P_{ow})
p. Auto-ignition temperature
q. Decomposition temperature
r. Viscosity

The SDS may not contain every item on the above list because information may not be relevant or is not available. When this occurs, a notation to that effect must be made for that chemical property. Manufacturers may also add other relevant properties, such as the dust deflagration index (Kst) for combustible dust, used to evaluate a dust's explosive potential.

10. Stability and Reactivity

    This section describes the reactivity hazards of the chemical and the chemical stability information. This section is broken into three parts: reactivity, chemical stability, and other. The required information consists of:

    a. Reactivity
        - Description of the specific test data for the chemical(s)
        - This data can be for a class or family of the chemical if such data adequately represents the anticipated hazard of the chemical(s), where available

    b. Chemical Stability
        - Indication of whether the chemical is stable or unstable under normal ambient temperature and conditions while in storage and/or being handled
        - Description of any stabilizers that may be needed to maintain chemical stability
        - Indication of any safety issues that may arise should the product change in physical appearance

    c. Other
        - Indication of the possibility of hazardous reactions, including a statement whether the chemical will react or polymerize, which could release excess pressure or heat, or create other hazardous conditions
        - A description of the conditions under which hazardous reactions may occur
        - List of all conditions that should be avoided (e.g., static discharge, shock, vibrations, or environmental conditions that may lead to hazardous conditions)
        - List of all classes of incompatible materials (e.g., classes of chemicals or specific substances) with which the chemical could react to produce a hazardous situation
        - List of any known or anticipated hazardous decomposition products that could be produced because of use, storage, or heating. (Hazardous combustion products should also be included in Section 5 (Fire-Fighting Measures) of the SDS.)

11. Toxicological Information

    This section identifies toxicological and health effects information or indicates that such data are not available. The required information consists of:

    a. Information on the likely routes of exposure (inhalation, ingestion, skin and/or eye contact). The SDS should indicate if the information is unknown

    b. Description of the delayed, immediate, or chronic effects from short- and long-term exposure

    c. The numerical measures of toxicity (e.g., acute toxicity estimates such as the LD50 (median lethal dose)) - the estimated amount [of a substance] expected to kill 50% of test animals in a single dose

d. Description of the symptoms. This description includes the symptoms associated with exposure to the chemical including symptoms from the lowest to the most severe exposure

e. Indication of whether the chemical is listed in the National Toxicology Program (NTP) Report on Carcinogens (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest editions) or found to be a potential carcinogen by OSHA

12. Ecological Information (Non-Mandatory)
This section provides information to evaluate the environmental impact of the chemical(s) if it were released to the environment. The information may include:

a. Data from toxicity tests performed on aquatic and/or terrestrial organisms, where available (e.g., acute or chronic aquatic toxicity data for fish, algae, crustaceans, and other plants or toxicity data on birds, bees, plants)

b. Whether there is a potential for the chemical to persist and degrade in the environment either through biodegradation or other processes, such as oxidation or hydrolysis

c. Results of tests of bioaccumulation potential, with referencing to the octanol-water partition coefficient (K_{ow}) and the bioconcentration factor (BCF), where available

d. The potential for a substance to move from the soil to the groundwater (indicate results from adsorption studies or leaching studies)

e. Other adverse effects (e.g., environmental fate, ozone layer depletion potential, photochemical ozone creation potential, endocrine disrupting potential, and/or global warming potential)

13. Disposal Considerations (Non-Mandatory)
This section provides guidance on proper disposal practices, recycling, or reclamation of the chemical(s) or its container, and safe handling practices. To minimize exposure, this section should also refer the reader to Section 8 (Exposure Controls/Personal Protection) of the SDS. The information may include:

a. Description of appropriate disposal containers to use

b. Recommendations of appropriate disposal methods to employ

c. Description of the physical and chemical properties that may affect disposal activities

d. Language discouraging sewage disposal

e. Any special precautions for landfills or incineration activities

14. Transport Information (Non-Mandatory)
    This section provides guidance on classification information for shipping and transporting of hazardous chemical(s) by road, air, rail, or sea. The information may include:

    a. UN number (i.e., four-figure identification number of the substance)

    b. UN proper shipping name

    c. Transport hazard class(es)

    d. Packing group number, if applicable, based on the degree of hazard

    e. Environmental hazards (e.g., identify if it is a marine pollutant according to the International Maritime Dangerous Goods Code (IMDG Code))

    f. Guidance on transport in bulk (according to Annex II of MARPOL 73/783 and the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (International Bulk Chemical Code (IBC Code))

    g. Any special precautions which an employee should be aware of or needs to comply with, in connection with transport or conveyance either within or outside their premises (indicate when information is not available)

15. Regulatory Information (Non-Mandatory)
    This section identifies the safety, health, and environmental regulations specific for the product that is not indicated anywhere else on the SDS. The information may include:

    a. Any national and/or regional regulatory information of the chemical or mixtures (including any OSHA, Department of Transportation, Environmental Protection Agency, or Consumer Product Safety Commission regulations)

16. Other Information
    This section indicates when the SDS was prepared or when the last known revision was made. The SDS may also state where the changes have been made to the previous version. You may wish to contact the supplier for an explanation of the changes. Other useful information also may be included here.

APPENDIX B: GLOVE USES AND SELECTION

There are many types of gloves available today to protect against a wide variety of hazards. The nature of the hazard and the operation involved will affect the selection of gloves. The variety of potential occupational hand injuries makes selecting the right pair of gloves challenging. It is essential that employees use gloves specifically designed for the hazards and tasks found in their workplace because gloves designed for one function may not protect against a different function even though they may appear to be an appropriate protective device.

A. WHEN TO WEAR GLOVES

1. Weigh out solid or powder chemicals
2. Prepare solutions
3. Handling acids, bases, corrosive materials
4. Access hot GC ovens or columns
5. Using cryogens or cold sample storage
6. Cleaning up spills
7. Discarding sharps and broken glass
8. Cleaning glassware and working areas

B. FACTORS THAT INFLUENCE GLOVE SELECTION

1. Type of chemicals handled
2. Nature of contact (total immersion, splash, etc.)
3. Duration of contact
4. Area requiring protection (hand only, forearm, arm)
5. Grip requirements (dry, wet, oily)
6. Thermal protection
7. Size, comfort, and dexterity
8. Abrasion/resistance requirements

C. TYPES OF GLOVES

1. *Leather, Canvas, or Metal Mesh Gloves*
   Sturdy gloves made from metal mesh, leather or canvas provide protection against cuts and burns. Leather or canvas gloves also protect against sustained heat.

   a. Leather gloves protect against sparks, moderate heat, blows, chips and rough objects.

   b. Aluminized gloves provide reflective and insulating protection against heat and require an insert made of synthetic materials to protect against heat and cold.

   c. Aramid fiber gloves protect against heat and cold, are cut- and abrasive-resistant and wear well.

   d. Synthetic gloves of various materials offer protection against heat and cold, are cut- and abrasive-resistant and may withstand some diluted acids. These materials do not stand up against alkalis and solvents.

2. *Fabric and Coated-Fabric Gloves*
   Fabric and coated fabric gloves are made of cotton or other fabric to provide varying degrees of protection.

   a. Fabric gloves protect against dirt, slivers, chafing and abrasions. They do not provide

sufficient protection for use with rough, sharp or heavy materials. Adding a plastic coating will strengthen some fabric gloves.

b. Coated fabric gloves are normally made from cotton flannel with napping on one side. By coating the unnapped side with plastic, fabric gloves are transformed into general-purpose hand protection offering slip-resistant qualities. These gloves are used for tasks ranging from handling bricks and wire to chemical laboratory containers.

3. *Chemical and Liquid Resistant Gloves*

Chemical-resistant gloves are made with different kinds of rubber: natural (latex), butyl, neoprene, nitrile and fluorocarbon (Viton); or various kinds of plastic: polyvinyl chloride (PVC), polyvinyl alcohol and polyethylene. These materials can be blended or laminated for better performance. As a general rule, the thicker the glove material, the greater the chemical resistance but thick gloves may impair grip and dexterity, having a negative impact on safety.

Examples of Chemical-Resistant Gloves:

Butyl Gloves

- Made of a synthetic rubber and protect against a wide variety of chemicals, such as peroxide, rocket fuels, highly corrosive acids (nitric acid, sulfuric acid, hydrofluoric acid and red-fuming nitric acid), strong bases, alcohols, aldehydes, ketones, esters, and nitro compounds.

- Butyl gloves also resist oxidation, ozone corrosion and abrasion, and remain flexible at low temperatures.

- Butyl rubber does not perform well with aliphatic and aromatic hydrocarbons and halogenated solvents.

Natural (Latex) Rubber Gloves

- Comfortable to wear, which makes them a popular general-purpose glove.

- They feature outstanding tensile strength, elasticity and temperature resistance.

- In addition to resisting abrasions caused by grinding and polishing, these gloves protect workers' hands from most water solutions of acids, alkalis, salts and ketones.

- Latex gloves have caused allergic reactions in some individuals and may not be appropriate for all employees.

- Hypoallergenic gloves, glove liners and powderless gloves are possible alternatives for workers who are allergic to latex gloves.

Neoprene Gloves

- Made of synthetic rubber and offers good pliability, finger dexterity, high density and tear resistance.

- They protect against hydraulic fluids, gasoline, alcohols, organic acids and alkalis.

- They generally have chemical and wear resistance properties superior to those made of natural rubber.

Nitrile Gloves

- Made of a copolymer and provides protection from chlorinated solvents such as trichloroethylene and perchloroethylene.

- Although intended for jobs requiring dexterity and sensitivity, nitrile gloves stand up to heavy use even after prolonged exposure to substances that cause other gloves to deteriorate.

- They offer protection when working with oils, greases, acids, caustics and alcohols

- Are generally not recommended for use with strong oxidizing agents, aromatic solvents, ketones and acetates.

4. *Insulating Rubber Gloves*
   See 29 CFR 1910.137 and the following section on electrical protective equipment for detailed requirements on the selection, use and care of insulating rubber gloves.

D. CARE OF PROTECTIVE GLOVES

1. Protective gloves should be inspected before each use to ensure that they are not torn, punctured or made ineffective in any way.

2. A visual inspection will help detect cuts or tears but a more thorough inspection by filling the gloves with water and tightly rolling the cuff towards the fingers will help reveal any pinhole leaks.

3. Gloves that are discolored or stiff may also indicate deficiencies caused by excessive use or degradation from chemical exposure.

4. Any gloves with impaired protective ability should be discarded and replaced.

5. Reuse of chemical-resistant gloves should be evaluated carefully, taking into consideration the absorptive qualities of the gloves. A decision to reuse chemically exposed gloves should take into consideration the toxicity of the chemicals involved and factors such as duration of exposure, storage and temperature.

6. Disposable gloves shall never be reused. These gloves should be disposed after each use.

TABLE 1: Recommended Glove Selection for Chemicals in the Laboratory

Type of Glove	Chemical Resistance	Recommended Use For	Not Recommended Use For
Butyl	Medium	▪ Glycol Ethers ▪ Ketones ▪ Esters	▪ Hydrocarbons ▪ Chlorinated Solvents ▪ Halogenated Compounds
Natural (Latex) Rubber	Low - Medium	▪ Bases ▪ Alcohols ▪ Dilute Water Solutions ▪ Aldehydes ▪ Ketones	▪ Oils ▪ Greases ▪ Organics
Natural Rubber Blends	Low	Overall better chemical resistance than Natural Rubber against: ▪ Bases ▪ Alcohols ▪ Dilute Water Solutions ▪ Aldehydes ▪ Ketones	▪ Oils ▪ Greases ▪ Organics
Neoprene	Medium	▪ Oxidizing Acids ▪ Anilines ▪ Phenol ▪ Glycol Ethers	▪ None
Nitrile	Medium	▪ Oils ▪ Greases ▪ Aliphatic Chemicals ▪ Xylene ▪ Perchloroethylene ▪ Trichloroethane ▪ Toluene	▪ Benzene ▪ Methylene Chloride ▪ Trichloroethylene ▪ Ketones
Polyvinyl Alcohol (PVA)	High	▪ Aliphatics ▪ Aromatics ▪ Chlorinated solvents ▪ Ketones (except acetone) ▪ Esters ▪ Ethers	▪ Light Alcohols
Polyvinyl Chloride (PVC)	Medium	▪ Strong Acids ▪ Strong Bases ▪ Salts ▪ Water Solutions ▪ Alcohols	▪ Plasticizers
Fluoroelastomer (Viton)	High	▪ Aromatics ▪ Chlorinated Solvents ▪ Aliphatics ▪ Alcohols	▪ Ketones ▪ Esters ▪ Amines
Norfoil (Silver Shield)	Very High	▪ Hazmat Work	▪ None

APPENDIX C: GLASSWARE SAFETY

A. Use careful handling and storage procedures to avoid damaging glassware. Inspect glassware before use. Discard damaged items. Support large pieces of glassware and full glassware from the bottom when carrying.

B. Use adequate hand protection (such as KEVLAR cut-resistant gloves) when inserting glass tubing into rubber stoppers or corks, or when placing rubber tubing on glass hose connections. Glass tubing should be fire-polished or rounded and lubricated with glycerin or water before inserting into rubber stoppers or rubber tubing. Keep hands close together to limit movement of glass should fracture occur. Consider the use of plastic or metal connectors.

C. Use a dustpan and broom to pick up broken glass. Do not pick up broken glass with your hands.

D. Dispose of broken glass in designated containers. Broken glass placed in regular trash cans poses a serious hazard to waste handling personnel.

E. Glassware and other reusable equipment must be triple rinsed before storage.

F. When using glassware under pressure or vacuum never exceed the manufacturer's established operating limits.

G. Provide proper instruction in the use of glass equipment designed for specialized tasks, which can represent unusual risks for the first-time user. For example, separatory funnels containing volatile solvents can develop considerable pressure during use.

H. Glassware is typically temperature sensitive and extremely rapid changes in temperature should be avoided.

I. When possible, glassware should remain freely vented. Even bottles that have vent filter assemblies are NOT freely vented and therefore can be subjected to pressure if the filter malfunctions.

J. Inspect bottle/filter assemblies prior to use to ensure that the vent and process lines are properly connected, vent lines are not obstructed (kinked, clamped, plugged), vent filters are not subjected to binding and there are no other situations that would inhibit normal venting.

K. Liquid transfer operations where there is a potential to accumulate positive pressure or vacuum shall be designed and maintained to limit the source pressure to the minimum required. At no time shall a source pressure be utilized that has the potential to exceed 40psi.

L. Glassware used in operations where pressure or vacuum is achievable should be placed in a protective shroud. Examples include:
   - Use plastic coated glassware when available.
   - Use plastic netting to contain glass fragments in the event of an implosion.
   - Use equipment inside the fume hood or biosafety cabinet with the sash closed.
   - Contain equipment inside stainless steel containers.
   - Work behind Plexiglas shielding. If shielding is used outside of a fume hood or biosafety cabinet, the set up should be such that operations / personnel flow are confined to areas in front of the shield.

M. Bottles 9 L to 45 L that may be subjected to positive pressure must be placed in a bottle protector.

APPENDIX D: COMPRESSED GAS HANDLING

Compressed gases present a unique hazard in that they present the potential for simultaneous exposure to both mechanical and chemical hazards. Additional hazards can arise from the flammability, reactivity, and toxicity of the gas. Asphyxiation can be caused by high concentrations of even "harmless" gases such as nitrogen. Finally, the large amounts of potential energy resulting from the compression of the gas makes compressed gas cylinders potential rockets/ bombs.

All gas cylinders MUST be labeled with a “Gas Cylinder Status Tag” upon receipt or delivery and shall be appropriately labeled as “FULL”, “IN USE”, or “EMPTY.” The date received shall also be written on the “Gas Cylinder Status Tag.”

The following procedures are recommended when handling compressed gases:

A. Gas cylinders/dewars are not to be stored in areas designated as egress corridors. Gases should be stored in areas with adequate ventilation and should be easily accessible for exchange.

B. All cylinders of compressed gas (including lecture bottles) shall be individually secured whether in storage or in use to prevent them from being knocked over accidentally. The cylinder should be secured at approximately 2/3 of its height using chain, plastic coated wire cable or other commercially available cylinder straps. They also may be secured to a fixed bench top using a clamping device, secured to the wall by a bracket, placed in a holding cage or have a non-tip base attached.

C. Gas cylinders/dewars should be clearly marked with the contents, to be easily and quickly identified. Such identification should be stenciled or stamped (non-removable labels and tags are acceptable) on the cylinder. Empty tanks should be marked as empty, and the valve caps replaced.

D. All piping leading from a compressed gas cylinder/dewar which is not clearly visible shall be labeled to identify the gas. Also, connections made to all flammable gas cylinders shall be made with metal tubing.

E. Cylinder valves should be opened slowly. When opening the valve on a cylinder containing an irritating or toxic gas (i.e., ethylene oxide, hydrogen fluoride, ammonia or chlorine) the user should only open the cylinder in a mechanically ventilated enclosure.

F. Cylinders of all gases having Health Hazard Ratings of 3 or 4 and cylinders of gases having a Health Hazard Rating of 2 with no physical warning properties should be kept in a continuously mechanically ventilated hood or other continuously ventilated enclosure. All cylinders containing flammable gases should be stored in a safe, well-ventilated area segregated by at least 20 feet from cylinders of oxidizers.

G. A cylinder should never be emptied to a pressure lower than 172 kPA (25psi). Empty cylinders should never be refilled by laboratory workers. Rather, the regulator should be removed, and the valve cap replaced. The cylinder should be clearly marked "EMPTY" and returned to a storage area for pickup. Cylinders of gases should be returned to the supplier when the expiration date or the maximum recommended retention period has been reached. In the absence of a maximum recommended retention time, a 36-month interval should be used.

APPENDIX E: SAFE USE OF LABORATORY HEATING DEVICES

Perhaps the most common types of laboratory equipment are devices used to supply heat needed to affect a reaction or a separation. Heat for laboratory procedures may be provided from ovens, hot plates, heating mantles, steam, oil baths, water baths or open flames. As a general reminder, employees should allow items to cool before handling. Guidelines for the safe use of these laboratory heating devices are listed below.

A. Steam Heating – If possible, use steam when temperatures of <100°C are required. By doing so, the potential shock or spark hazard of electrically powered heating devices is eliminated.

B. Electrical Heating Devices – The actual heating element should be enclosed in a glass, ceramic, or insulated metal case to protect against electric shock or spark.

   1. Ovens – Never use laboratory ovens for human food preparation. Heating elements and temperature controls must be separated from the interior environment. Ovens should be vented directly to an exhaust system to avoid volatilized substances from being emitted to the laboratory. Volatile flammable materials should not be heated in an oven.

   2. Microwave Ovens – Never use laboratory microwave ovens for human food preparation. Never operate with the door open. Wires and other objects should not be placed in the seal of the door. Metal objects should not be used in the microwave. Venting must be provided for heated containers. Sealed or screw cap containers should not be heated using a microwave. Remove or replace the lid with a loose-fitting plug such as foam- loosened lids may not ensure adequate venting and may reseat during heating. Do not overheat samples. Use the "defrost" or "low power setting" for more controlled heating whenever possible. Heat only aqueous based solutions. Avoid heating combustible and flammable materials and organic based solvents. Never attempt a chemical reaction within a microwave oven. Material with high water content can be superheated and boil over if moved too soon after heating. Allow for cooling time, use lower heat settings and wear thermal resistant gloves to protect against burns when removing items.

   3. Hot Plates – Hot plates (with enclosed heating elements) should be used when temperatures over 100°C are required. Temperature and stirrer controls should be clearly distinguished to avoid inadvertent operation.

   4. Heating Mantles – Ensure that the fiberglass cloth is not worn or damaged inside the mantle. Ensure that no liquids are spilled into the mantle to avoid shock hazard. Never exceed the input voltage recommended by the mantle manufacturer. If the mantle is constructed with an outer metal case (protecting the fiberglass element), the outer metal case should be grounded.

C. Water / Oil Baths – Care must be taken to avoid spilling water or other volatile substances into the bath, which may cause splatter. Oil bath temperature should always be monitored to ensure the oil flash point is not exceeded. The bath should be capable of being lowered away from the reaction in case of overheating. The bath should be contained in secondary containment to avoid spillage of hot oil / water in the event of an accident.

D. Open Flames – Burners with open flames may also be used for heating non-flammable substances, but their use is discouraged. They should only be used in a carefully controlled environment when no alternatives are available.

APPENDIX F: WORKING SAFETY WITH CRYOGENIC MATERIALS

Cryogens are gases that have been cooled until they are in liquid or solid form. These substances can cause extensive damage to exposed skin and may also present other hazards including toxicity, oxygen deficiency and explosivity. Commonly used cryogens include liquid nitrogen (boiling point of -195.8 °C), liquid helium (boiling point of -268.93 °C), and dry ice (sublimation point at temperatures above -78.5 °C).

All cryogenic liquids are gases at normal temperatures and pressures and produce large amounts of gas when they vaporize. Liquid nitrogen, a commonly used cryogenic material, is colorless, odorless and tasteless. It is non-flammable, physiologically inert and non-toxic. It is an extremely cold liquid with a boiling point of -196ºC = -320ºF.

A. Requirements for Use of Cryogenic Liquids
   1. It is the responsibility of both the laboratory supervisor and/or laboratory employees to ensure training on proper use and safe handling of cryogenic liquids.

   2. Researchers shall wear the required personal protective equipment (PPE) defined in *Section II.E*.

   3. All accidents (injuries, spills, and near miss incidents) must be reported to the laboratory supervisor and chemical hygiene officer within 24 hours after the incident occurs. Call Safety and Security (x4911) or emergency personnel (911) for emergency medical assistance. In addition, an incident report form (Appendix J) must be completed and filed with the laboratory manager.

   4. In the event of accidental skin or eye contact, immediately flood the area with large quantities of unheated water. Do not rub or massage affected parts of the body. Call for medical assistance or seek immediate medical attention at Health Services.

B. General Information
   1. Temperature Related Hazards
      a. Low temperature of cryogens may cause burn-like damage (frostbite) to skin by contact with the fluid, surfaces cooled by the fluid, or evolving gases. Skin can freeze and adhere to liquid cryogen cooled surfaces causing tearing on removal.

      b. Low temperature of the vapor may cause damage to soft tissues (e.g., eyes and lungs).

      c. Soft materials (e.g., rubber and plastic) become brittle when cooled by cryogens and may shatter.

   2. Vapor Related Hazards
      a. If allowed to depressurize, cryogenic liquids can rapidly expand which can result in violent explosions of sealed or insufficiently vented containers.

      b. Large volumes of gas are evolved from small volumes of liquid cryogens (e.g., One liter of Nitrogen yields 650 liters of gas at STP.) The production of gas vapors may decrease the oxygen content in the air and make the atmosphere incapable of sustaining life, causing asphyxiation (suffocation) without warning. Oxygen concentrations below 16% by volume can cause dizziness, rapid heartbeat, nausea, vomiting, disorientation, mental confusion, loss of consciousness and death. There is no warning. Oxygen has no odor, color or means of determining concentration without direct measurement.

      c. Flammable gas leaks can cause an explosion hazard in the presence of a spark or ignition source.

d. Because the boiling point of oxygen is above that of nitrogen, oxygen can condense from the air into liquid nitrogen. If left uncovered for an extended period of time, liquid oxygen can build up to levels which may cause violent reactions with organic materials (i.e., a severe clothing fire could result).

C. Personal Protective Equipment and Ventilation

1. Prevent Exposure and Contact with Cryogenic Liquids

a. Use liquid repellent cryogenic gloves to protect hands. The gloves should be loose fitting for easy removal in case of an emergency. Gloves may also have an elastic cuff.

b. A splash resistant lab coat is recommended to minimize skin contact. A floor length splash resistant apron can also be worn. Ensure pants are over the shoe and/or boot to prevent shoes from filling in the event of a spillage.

c. Avoid wearing clothing, jewelry, and other items that are capable of trapping or holding cryogenic fluid close to the body.

d. Wear safety glasses with side shields, safety goggles, and/or a face shield to protect from inadvertent splashes.

e. As with all lab work, closed toed shoes that cover the top and back of the foot are required.

f. Use tongs or other devices to avoid direct contact when handling containers or cold metal parts.

2. Ensure Adequate Ventilation in Rooms where Liquid and Solid Cryogens are Used and Stored

a. Never use or store cryogenics in a confined space, only in well-ventilated areas. Never store dry ice or samples/containers packed in dry ice in poorly ventilated areas or rooms with re-circulating ventilation such as walk-in freezers or refrigerators or closed staging/storage rooms, etc.

b. In some cases, oxygen monitors are recommended to directly measure the oxygen concentration in a room.

c. Dry ice must be sublimated in the laboratory, preferably in the chemical fume hood.

d. Never dispose of liquid nitrogen by pouring it onto the floor or in the sink.

e. It is important that liquid cryogens are handled in lab environments that maintain appropriate fresh air circulation as designed and operate properly for a normally occupied space.

D. Alarms, Storage, and Transport

1. Alarms

a. Post warning signs where liquid cryogens are stored and are in use.

b. DO NOT ENTER during an alarm state. Alarm indicates that a potentially hazardous atmosphere exists.

c. If the alarm is activated while in the room, leave the area immediately and call Safety and Security (x4911) or emergency personnel (911).

d. Only trained emergency response personnel are permitted to enter a potentially hazardous environment. Re-entry is prohibited until a thorough investigation is complete and the alarm condition has been resolved.

2. Dewars
   a. Do not store liquid nitrogen, liquid helium, or dry ice in any container with tight fitting lid. A loose-fitting lid helps in preventing air or moisture from entering the container and at the same time allows pressure to escape.

   b. Use only dewars that are compatible with the cryogens being used. Never use an ordinary household thermos bottle.

   c. Glass dewars must be protected against the possibility of flying glass fragments. Seal exposed glass in a metal insulated can or wrap with adhesive tape.

   d. Warm dewars should be filled slowly to reduce temperature shock effects to minimize boiling and splashing.

3. Transferring Cryogenic Liquids
   a. Use only suitable vessels for the handling and/or transporting of cryogenic liquids

   b. Do not use hollow rods or tubes as dipsticks

   c. Make sure all parts of the pressurized system are designed to accommodate the cryogen temperature

   d. Make sure the cryogenic system has a separate pressure relief device manufactured for the material in use for each component or segment of piping and hose that will be isolated by a valve

   e. Pre-cool receiving vessel to avoid thermal shock and splashing

   f. Do not fill cylinders more than 80% of capacity

   g. Keep equipment clean

   h. When discharging cryogenic liquids, purge the line slowly. Only use transfer lines specifically designed for cryogenic liquids

   i. Only elevators can be used to transport liquid nitrogen, liquid helium, or dry ice. Elevators are essentially designed to fulfill material handling requirement of industry, building, etc. (passengers shall not ride in the elevator with liquid nitrogen)

   j. Use the buddy system when transporting liquid nitrogen in freight elevator. Plan for someone to send the elevator to a receiving person waiting on the desired floor

   K. Handle liquid cylinders carefully; do not roll, drop or tip them to the sides

APPENDIX G: CHEMICAL STORAGE LIMITS & GUIDELINES

Proper storage of chemicals will minimize hazards to personnel, laboratory/office areas, and the environment. The quantity of chemicals stored in a laboratory should be kept to a minimum. Chemicals should be stored by methods and locations appropriate to their hazard classification.

Every chemical in the laboratory should have a defined storage place and should be returned to that location after use. Storing chemicals on bench tops is not a recommended practice due to the possibility of spill and breakage. One working day's supply is permitted to be located on the bench top; however flammable chemical containers must be returned to designated storage locations at the end of the working shift.

Chemical fume hoods are not considered an appropriate storage location. Storing chemicals in fume hoods could result in airflow turbulence and/or inadequate face velocities and clutter could contribute to increased incidence of spills, accidental contact, and fire hazard.

In order to use chemical storage space efficiently, compatible materials should be stored according to container size. Shelves should be sized and spaced appropriately. Storing a combination of large and small containers of chemicals on the same shelf makes retrieval difficult and increases the chances of bottle breakage. If it is necessary to store varying sizes together, keeping larger containers toward the back will help minimize accidental breakage.

The storage density of small bottles of chemicals can be increased by storing them in drawers mounted on heavy-duty, full extension glides (complete with drawer stops). This allows convenient access to all parts of the drawer.

A. RESPONSIBILITIES

It is the responsibility of all employees, including those responsible for procurement of chemicals, to follow the procedures listed in the chemical hygiene plan for the specific laboratory including procurement, distribution, and storage of chemicals.

B. PROCEDURES

1. Flammable Liquid Storage

a. Flammable and combustible liquids are defined as indicated on container labels and must be stored in flammable storage cabinets or approved explosion-proof or flammable material refrigerators/freezers.

b. Flammable liquids may be received and stored in the following types of containers:

- Glass
- Plastic
- Flammable (Class 1A) - 1 gallon or less
- Flammable (Class 1B and 1C) - 5 gallons or less under the following conditions:
  - Liquid is maintained in original shipping container (DOT exemption in effect for shipment in polyethylene containers and is identified as meeting the requirements of the exemption).
  - Container storage and use area has fire suppression system (sprinkler system) designed for the quantities used/stored
  - Containers are relocated from laboratories to a safe storage location when not in use at a minimum at the end of each day. Safe storage locations may include approved flammable liquid storage cabinets or inside flammable liquid storage rooms

- If the liquid is kept in the plastic container, dispensing directly from a flammable liquid storage cabinet is recommended

- Employees should not attempt to fight fires (involving the plastic container) using fire extinguishers and must evacuate at time of initial fire detection

- Container is not to be refilled with flammable liquid

- Drums (metal)
- Pressurized liquid dispensing containers (PLDC)
- Metal containers used for flammables should be properly grounded when in use

2. DESIGN OF FLAMMABLE STORAGE CABINETS
    a. Ventilation of storage cabinets is not required for fire protection. If ventilation is needed to control odors, corrosion, or to prevent flammable concentrations of vapors, a mechanical system should be utilized to provide effective exhaust of the cabinet. Exhaust fans should be spark-proof and the motor should be explosion-proof. The cabinet and the duct should be fire resistant.

    b. If the cabinet is not mechanically vented, the vent openings should be sealed with the bungs supplied with the cabinet or with bungs specified by the manufacturer of the cabinet. Flammable storage cabinets should also be grounded only if used for dispensing.

    c. Flammable storage cabinets should be properly grounded especially if flammable materials are going to be dispensed directly from that cabinet as recommended above.

3. STORAGE OF ACIDS, BASES AND STANDARD REAGENTS
    a. Strong acids and bases may be stored in the base of chemical fume hoods but should be segregated from each other to prevent cross-mixing in the event the chemicals leak, or the containers break.

    b. Weak acids and bases such as citric acid and sodium carbonate may be stored with other low-hazard reagents.

    c. Open shelves for chemicals should be located out of normally traveled routes and have a ¾- inch lip to prevent movement over the edge due to vibration.

4. COMPRESSED GAS CYLINDERS
    a. Cylinders of compressed gas should be individually strapped, chained or supported to prevent them from being knocked over accidentally. The restraining mechanism should be at approximately 2/3 its height of the cylinder. Cylinders should be stored in an area with adequate room ventilation to remove leaking gas and should be easily accessible for exchange of cylinders.

    b. Only cylinders designated and safeguarded in accordance with DOT regulations should be used for compressed gas. These cylinders are marked with the DOT specification number and usually with the design service pressure of the cylinder. Cylinders under DOT carry a red label for flammable gases, a green label for nonflammable gases, a white label for poison gases,

or a corrosive or flammable liquid label. Absence of a label does not indicate that a cylinder is not hazardous; it may indicate that the cylinder is not subject to DOT regulations or does not require a label due to the pressure. Also, a green label does not mean that the gas is not an explosion hazard.

c. The contents of the compressed cylinder should be clearly identified. Empty tanks should be marked as empty, and the valve cap replaced. A cylinder should never be emptied to a pressure lower than 172 kPA (25 psi). Empty cylinders should never be refilled by laboratory workers. All gas lines leading from a compressed gas cylinder which are not clearly visible should be labeled to identify the gas, laboratory served, and relevant emergency telephone numbers. Also, all connections to flammable gas cylinders should be made with metal tubing.

d. Cylinders of all gases having Health Hazard Ratings of 3 or 4 and cylinders of gases having a Health Hazard Rating of 2 with no physical warning properties should be kept in a continuously mechanically ventilated hood or other continuously ventilated enclosure. All cylinders containing flammable gases should be stored in a safe, well-ventilated place segregated by at least 20 feet from cylinders of oxidizers.

e. Cylinders of gases should be returned to the supplier when the expiration date of the maximum recommended retention period has been reached, if applicable (i.e., medical gases).

5. HIGHLY REACTIVE CHEMICALS AND CHEMICAL HAZARDS

a. *Organic Peroxides and Picric Acid*
Peroxide forming chemicals and picric acid and its salts are classes of compounds with unusual stability problems. They are among the most hazardous materials handled within the laboratory. Do not attempt to move or open any old containers of peroxidizables or picric acid.

b. *Hazards of Picric Acid*
Picric acid is a shock sensitive explosive that is susceptible to the formation of picrate salts which can be more shock sensitive than the acid itself. Picric acid is stabilized by the addition of water and should only be purchased as an aqueous solution or a water-damp solid (>30%water). If picric acid is needed:

- Solid material should be kept water wet
- Do not use metal spatulas to avoid producing metal picrate salts
- Containers should be date-marked when purchased and disposed within 6 months
- Do not purchase larger amounts of picric acid than needed
- When vacating a laboratory, ensure that picric acid containers are not left in an "orphaned" state

c. *Hazards of Peroxidizable Compounds*
Peroxide-forming compounds could form shock-sensitive explosive peroxides under normal storage conditions. The risk associated with peroxide formation increases if the peroxide crystallizes or becomes concentrated by evaporation or distillation. Factors that affect the rate of peroxide formation include exposure to air, light or contamination from metals. Do not open a liquid peroxide-forming chemical if crystals or a precipitate are present.

General Recommendations:

- *Minimize Inventory*
  Since peroxidizable and picrate chemicals deteriorate with age, it is advisable to restrict the amounts of these chemicals to ensure that they are used completely before they can become hazardous. A one-month supply should be more than adequate for most laboratories. Substitution can be the best way to avoid or reduce the hazard. Speak to chemical suppliers or your supervisor to find out if safer substitutes are available.

- *Date and Purge*
  Containers of peroxidizable chemicals must be dated when received and AGAIN when opened. Many commercially purchased ethers do not have a bottling or expiration date. The receipt date ensures that old containers can be properly identified for disposal. Opened containers need to be labeled with an opening date since the exposure to oxygen increases at that point. Unopened containers may be kept for one year after receipt OR until the expiration date whichever occurs first, and then disposed of in accordance with safety procedures. Regularly scheduled chemical cleanouts can assist in identifying and disposing of these chemicals prior to them becoming a hazard.

- *Storage Temperature*
  Do not store liquid or solutions of peroxides at a temperature below that at which the peroxide freezes or precipitates. Peroxides in this form are extremely shock and heat- sensitive. Refrigerated storage of peroxides or other flammable chemicals must be ONLY in explosion-proof units. Grignard reagents are peroxidizable compounds, and they should NOT be stored refrigerated.

- *Old Containers*
  Old containers which have been found during clean-ups and lab shutdowns should be treated with EXTREME CAUTION. If the containers appear old, or have visible crystals, call the Safety Officer and/or the chemical hygiene officer and explain the situation. In extreme situations a special disposal team may have to be called in. Do not attempt to move or open any old containers of peroxidizables or picric acid.

Additional Guidance for Peroxide Forming Chemicals:

- These compounds are not to be used if a precipitate forms or oily viscous layer appears.

- Do not attempt to open a container when a cap is stuck, rusted or encrusted with any scale.

- Store away from strong sources of light, heat and air (install cap/lid when not in use).

- Do not use metal spatulas to handle peroxides. Do not use magnetic stirring bars. Use of these can lead to explosive decomposition. Use ceramic, Teflon or wooden spatulas and stirring blades. Only use blades if compound is confirmed to not be shock sensitive.

- Avoid friction, grinding and all forms of impact, especially solid peroxides. Glass bottles with screw caps or glass stoppers are not to be used. Polyethylene bottles with screw caps are permitted.

- To minimize decomposition, store at lowest possible temperature consistent with their solubility or freezing point. Do not store liquids equal to or less than the freezing temperature or at which precipitation forms.

- Consult the Safety Officer or chemical hygiene officer with any questions regarding materials that are found and are of unknown origin or exceed their expiration date.

- Best practice is to handle only one open can of peroxide forming compound in the laboratory fume hood at a time.

TABLE 2: Examples of Common Compounds That Form Peroxides and Recommended Maximum Storage Times

Discard within 3 MONTHS after container is Opened	Discard 6 MONTHS after container is Opened	Normal Liquids: Discard 6 MONTHS after container is Opened
Severe Peroxide Hazard on Store with Exposure to Air	*(Peroxide Hazard on Concentration) Do Not Distill or Evaporate Without Fire Testing for the Presence of Peroxides*	*Hazard of Rapid Polymerization Initiated by Internally Formed Peroxides*
Divinyl acetylene Ethyl ether Isopropyl ether Potassium amide Potassium metal Sodium amide Vinylidene chloride	Acetaldehyde diethyl acetal Cumene Cyclohexene Cyclopentene Decalin Diacetylene Dicyclopentadiene Diethyl ether Diethylene glycol dimethyl ether Dioxane Ethylene glycol ether acetates Ethylene glycol monoethers Ethylene glycol dimethyl ether Furan Methylacetylene Methylcyclopentane Methyl isobutyl ketone Tetrahydrofuran Tetralin Vinyl ethers	Chloroprene Styrene Vinyl acetate Vinyl pyridine

6. EXPLOSIVE COMPOUNDS

   Compounds containing the following functional groups are sensitive to heat and shock: acetylide, azide, diazo, halamine, nitroso, ozonide and peroxide. These compounds should be stored according to label directions. If a container is found past the recommended expiration date and/or has signs of crystallization, do not move the container. Notify the chemical hygiene officer and Safety Officer.

7. INCOMPATIBLE CHEMICALS

   Incompatible chemicals must be stored separately in order to ensure that contact cannot be made in case of spillage. Such contact could result in a serious explosion or the formation of substances that are highly toxic or flammable (see Appendix H, Table 2, for incompatible chemical lists).

8. CRYOGENIC MATERIALS

Ensure adequate ventilation in rooms where liquid and solid cryogens are used and stored. Never use or store cryogenics in a confined space. Never store dry ice or samples/containers packed in dry ice in poorly ventilated areas or rooms with re-circulating ventilation such as walk-in freezers or refrigerators or closed staging/ storage rooms, etc. In some cases, oxygen monitors are required.

- Dry ice should be sublimated in the laboratory, preferably in the chemical fume hood.
- Clearly post warning signs at rooms where liquid cryogens are stored and are in use.
- DO NOT ENTER during an alarm state. Alarm indicates that a potentially hazardous atmosphere exists. If the alarm is activated while in the room, leave the area immediately.
- Report incident to contact personnel as indicated on the area sign or the Command Center x26100.
- Only trained emergency response personnel are permitted to enter a potentially hazardous environment.
- Re-entry is prohibited until a thorough investigation is complete and the alarm condition has been resolved.

9. CHEMICAL INVENTORY

Chemical Inventory lists should be maintained for each laboratory. Chemical inventory lists are continually updated throughout the year and reviewed annually. Lists are available to all laboratory supervisors, employees, and workers and are distributed and/or kept in the following locations:

- Office of the Departmental Secretary (Lynn 154)
- Office of Safety and Security (Lower Level- Rich Hall)
- Office of the Laboratory Managers/Chemical Hygiene Officer (Heim 212)
- City of Williamsport Fire Department
- Flammable, Oxidizer, and General Chemical Storage Rooms (Heim Ground Floor)

APPENDIX H: CHEMICAL STORAGE AND CHEMICAL COMPATIBILITY

When certain hazardous chemicals are stored or mixed together, violent reactions may occur because the chemicals are unsuitable for mixing or are incompatible. Classes of incompatible chemicals should be segregated from each other during storage, according to hazard class.

No single method of determining chemical compatibility is perfect. The reasons for this are varied and include:

- Many chemicals belong to more than one hazard class. This can lead to confusion as to which class is appropriate for the chemical in question. Examples: Nitric acid is both an acid and an oxidizer; Benzoyl chloride is a combustible liquid, a corrosive, and a lachrymator.

- The hazard class that is most important can change depending on factors such as quantity of material, and other chemicals in the storage area.

- Not all chemicals in each class are compatible. For example, sodium dichloroisocyanurate and calcium hypochlorite are both oxidizers and belong to no other class of chemical, yet the mixing of these two materials can lead to the formation of nitrogen trichloride, a shock sensitive explosive.

- Rigid adherence to a classification scheme often leads to inefficient work practices. An example is the prohibition of storing acids and bases together. While this is a good practice, it is not practical when one has numerous dilute solutions, as in atomic absorption standards made up in both dilute nitric acid and dilute ammonium hydroxide. Clearly, mixing of these acid and base solutions will not result in a hazardous reaction, and forcing workers to store such standards separately is inconvenient and unnecessary.

Relying solely on compatibility classification schemes might provide a false sense of security and it is important that those working with chemicals and those responsible for using and maintaining chemical storage facilities be familiar with the limitations of the classification system and the properties of the materials they are working with.

The following guidelines are provided for the safe storage of hazardous materials in accordance with their hazard classes:

Acids:

- Segregate acids from bases and reactive metals such as sodium, potassium, magnesium, etc.
- Segregate oxidizing acids (e.g., nitric acid) from organic acids, flammable and combustible materials
- Segregate acids from chemicals which could generate toxic or flammable gases upon contact, such as sodium cyanide, iron sulfide, etc.

Bases:

- Segregate bases from acids, metals, organic peroxides and easily ignitable materials

Solvents (Flammable and Halogenated Solvents):

- Segregate from oxidizing acids and oxidizers
- Keep away from any source of ignition (heat, sparks, or open flames)

Oxidizers

- Store in a cool, dry place
- Keep away from combustible and flammable materials
- Keep away from reducing agents such as zinc, alkali metals, and formic acid

Water Reactive Chemicals

- Store in a cool, dry place away from any water source
- Make certain that a Class D fire extinguisher is available in case of fire

Pyrophoric Substance (react with the air to ignite when exposed, e.g., white phosphorus of tert-Butyl Lithium)

- Store in a cool, dry place making provisions for an airtight seal

Peroxide Forming Chemicals

- Store in airtight containers in a dark, cool, and dry place
- Label containers with receiving, opening, and disposal dates
- Periodically test for the presence of peroxides

Organic Peroxides

- Store in area such as a refrigerator where the temperature will remain below the self-accelerating decomposition temperature

The table below shows combinations of some of the more commonly encountered chemicals that should be avoided. Before mixing any chemicals, refer to this partial list, the SDS of the chemicals, or call the Office of Environmental Health and Safety to verify compatibility.

TABLE 3: Chemical Compatibility and Storage

Chemical	Keep Out of Contact With:
Acetic Acid	Chromic acid, nitric acid hydroxyl compounds, ethylene, glycol, perchloric acid, peroxides, permanganates
Acetone	Concentrated nitric and sulfuric acid mixtures
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali Metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, the halogens
Ammonia anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium Nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids
Bromine	Same as chlorine
Calcium Oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents.
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic Acid	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine Dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide

Cumene Hydroperoxide	Acids, organic or inorganic
Cyanides	Acids
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic Acid	Nitric acid, alkali
Hydrofluoric Acid	Ammonia, aqueous or anhydrous
Hydrogen Peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases
Hydrogen Sulfide	Fuming nitric acid, oxidizing gases, acetylene, ammonia (aqueous or anhydrous), hydrogen
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric Acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic Acid	Silver, mercury
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Perchloric Acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium Chlorate	Sulfuric and other acids
Potassium Permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium Peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)
Tellurides	Reducing Agents

Reference:

From Manufacturing Chemists' Association, Guide for Safety in the Chemical Laboratory, pp. 215 – 217.

APPENDIX I: DEPARTMENT OF CHEMISTRY, BIOCHEMISTRY AND BIOLOGY INCIDENT REPORT FORM

LYCOMING COLLEGE DEPARTMENTS OF CHEMISTRY, BIOCHEMISTRY AND BIOLOGY

INJURY/ILLNESS INCIDENT REPORT FORM

Please print all information in blue or black ink.
This form shall be used for all Laboratory Workers, including supervisors, employees, students, and visitors, within the Lycoming College Departments of Chemistry, Biochemistry and Biology.

Today's date: / /				Date of Injury: / /
❑ Report Only-No Medical Treatment	❑ Medical Treatment On-Campus		❑ Medical Treatment Off-Campus	

PERSONAL INFORMATION

Employee Last Name: First: Middle:			❑ Mr. ❑ Miss ❑ Mrs. ❑ Ms.	Marital status (circle one) Single / Mar / Div / Sep / Wid
Employee ID #:	Social Sec. No. (last 4 digits):	Birth date: / /	Sex: ❑ M ❑ F	Cell Phone No.: ( )
Street address:				Home Phone No.: ( )
P.O. Box:	City:		State:	ZIP Code:
Occupation:	Department/Division:			Date of Hire: / /
Supervisor's Name:				Supervisor's Phone No.: ( )

INJURY OR ILLNESS INFORMATION

A personal statement written by the injured or ill worker in his/her own words detailing the incident should be attached to this form.

Time worker began job/class: ❑ a.m. ❑ p.m.	Time of injury: ❑ a.m. ❑ p.m.	Did the worker return to job/class? ❑ Same Day ❑ Next Day ❑ Date Returned:
Did the employee have lost time? ❑ Yes ❑ No ❑ N/A	If yes, date lost time began: / /	

Type of injury or illness: Specific Injury	**Type of injury or illness: Occupational Diseases or Cumulative Injury**	**Body part(s) affected: (circle L or R as applies)**	**Cause of injury:**
❑ No physical injury	❑ Carpal tunnel syndrome	❑ Abdomen	❑ Burn or scald – heat or cold exposure
❑ Abrasion (scrape or scratch)	❑ Dermatitis (skin rash, redness, swelling, etc.)	❑ Ankle (L or R)	❑ Caught in or between objects, materials or equipment
❑ Amputation	❑ Mental disorder	❑ Arm (L or R)	❑ Cut, puncture, scrape injured by object
❑ Angina pectoris (chest pain)	❑ Respiratory disorders (gases, fumes, chemicals, etc.)	❑ Back – lower	❑ Exposure to Irritant – eyes, skin, etc.
❑ Asphyxiation	❑ Poisoning - chemical	❑ Back - upper	❑ Fall or slip injury
❑ Bite	❑ Poisoning - metal	❑ Chest	❑ Inhalation
❑ Concussion	❑ Other (please specify):	❑ Ear (L or R)	❑ Motor vehicle
❑ Contusion (bruise)		❑ Elbow (L or R)	❑ Strain/sprain
❑ Crushing		❑ Eye	❑ Striking against or stepping on objects
❑ Dislocation		❑ Face	❑ Struck or injured by object
❑ Electric shock		❑ Finger(s)	❑ Other (please specify):
❑ Foreign body		❑ Foot (L or R)	
❑ Fracture		❑ Hand (L or R)	
❑ Freezing		❑ Head	
❑ Hearing loss or impairment		❑ Hip	
❑ Heat prostration		❑ Knee (L or R)	
❑ Hernia		❑ Leg (L or R)	
❑ Infection		❑ Mouth	
❑ Inflammation		❑ Neck	
❑ Laceration (cut)		❑ Nose	
❑ Poisoning (not OD or cum. Injury)		❑ Scalp	
❑ Puncture		❑ Shoulder	
❑ Rupture		❑ Toe(s)	
❑ Severance		❑ Tooth/Teeth	
❑ Sprain/Strain		❑ Wrist (L or R)	
❑ Syncope (loss of consciousness)		❑ Other (please specify):	
❑ Vision loss			
❑ Other (please specify):			

LYCOMING COLLEGE DEPARTMENTS OF CHEMISTRY, BIOCHEMISTRY AND BIOLOGY

INJURY/ILLNESS INCIDENT REPORT FORM

Where did the injury occur? (interior/exterior building, outdoor location, vehicle or other location; please be specific):
How did the injury occur? What was the worker doing? List any existing unsafe acts or unsafe conditions.
Specify any tools, equipment, chemicals or other agents the worker was using when the injury or illness exposure occurred.
Did any equipment malfunction or was there any damage to equipment or property? ❑ Yes ❑ No If yes, please explain:
Were there safeguards in place? ❑ Yes ❑ No If yes, describe the safeguards and how they were to be used (e.g. use of handrails, personal protective equipment, etc.):
What action will be taken to prevent recurrence? Who is responsible to implement the action and by what date?

List any witnesses to the injury: (specific names and contact info.)	

MEDICAL TREATMENT

Initial Treatment: (On-Campus)	❑ No Medical Treatment	❑ Minor Administered by Worker or Supervisor	❑ Lycoming College Health Services
Initial Treatment: (Off-Campus)	❑ UPMC Susquehanna Williamsport Hospital ER	❑ The Work Center at UPMC Susquehanna Divine Providence Hospital	
	❑ Workers Comp Panel Provider (name, if applicable):		
	❑ Other Medical Treatment Provider (name and address, if applicable):		

Date of First Treatment: / /	Date of Follow-up Treatment: / /

SIGNATURES REQUIRED

Injured or Ill Workers's Signature _____ Date _____

Supervisor's Signature _____ Date _____

Security Officer Signature (if Security called to assist in absence of Supervisor) _____ Date _____

APPENDIX J: EMERGENCY ACTION PLAN

All information for Lycoming College's Emergency Preparedness can be found at https://www.lycoming.edu/emergency-preparedness/ and the Emergency Response Reference Page at https://www.lycoming.edu/emergency-preparedness/reference-page.aspx

During an emergency, please do your part to maintain your composure, act responsibly, and provide aid according to your skills and abilities and with the concurrence of on-the scene emergency responders.

It is recommended that all members of the College community become familiar with the location of fire extinguishers, fire blankets, and red fire alarm pull boxes in their buildings in case of emergency.

Emergency Calls

The first person to discover an emergency situation is responsible for immediately calling Safety and Security (ext. 4911 or 570-321-4911) and/or dialing 911 from a safe location. Classroom phones and building courtesy phones are located throughout all buildings on campus with direct dial access to 911 and ext. 4911. For severe emergencies, dial 911 first, then contact Safety and Security.

During the call provide the following information:

- Name
- Describe the nature and severity of emergency
- Campus Location
- Stay online with dispatcher until emergency personnel arrive
- Have someone flag-down emergency personnel at nearest entrance

Primary and Secondary Exit Routes

Exit routes should be posted in each classroom and in hallways of all buildings on campus.

Evacuation Procedures

Never assume a warning is just a drill. Immediately leave the building through the nearest available exit.

Hazardous Material Release

1. Evacuation: Spills that occur inside the building. Evacuation should occur using proper evacuation routes.

2. Shelter-in-Place: Spills that occur outside the building. Close and seal all exterior doors and windows. Remain in place until advised by emergency personnel.

Other Emergencies

Detailed guidelines for all other emergency situations can be found in the Emergency Procedures Manual including Fire, Bomb Threat, Active Shooter, Earthquakes, Severe Weather, Hostage Situation, Power Failures, etc.

Emergency Resource Team Leaders

Dr. Kent Trachte	President of Lycoming College	Emergency Director
Dan Miller	Vice President for Student Life	Emergency Coordinator
Holly Bleam	Safety and Security	Coordinator