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**Department of Chemical Engineering
Michigan Technological University
Houghton, MI**

**SAFETY MANUAL
For Faculty, Staff, and Students**

Includes Chemical Hygiene Plan

For emergency information, turn to the next page.

May, 2008

Chemical Hygiene Officer:

David A. Zei
305A Chemical Sciences Building
487-2362

Manager of Laboratory Facilities:

David Caspary
B004 Chemical Sciences Building
487-2022

WHAT TO DO IF SOMEONE IS HURT

More detailed emergency response information is provided on the following page.

If an MTU employee, student or visitor becomes seriously ill or injured on campus, here is what you should do:

1. If the injury or illness is life threatening, or if you are in doubt, call 911 and ask for an ambulance. Be sure to let the dispatcher know if you need additional help, such as the fire department or Public Safety officers. In the event of a chemical spill, the dispatcher will notify Occupational Safety.
2. Work-related injuries or illnesses that require immediate care but are not life threatening should be referred to University Health Services (487-2683). Students may use the Health Center for all types of medical care - University employees are treated there for work-related injury or illness only. Illnesses that are not work related should be treated by your personal physician.

Be sure to call University Health Services first, at 487-2683, and tell them what has happened. Health Services may be able to treat the victim, or they may recommend that the victim go to the hospital. In many cases, the victim should not drive. If an injured employee goes to Health Services, the supervisor should sign an authorization form or call ahead to notify staff that the victim has permission to receive treatment.

3. Supervisors must fill out an incident investigation form in the event of an employee accident or illness (a copy of this form is contained within this manual). For accidents involving a student in class, the instructor must complete the form.

For other incidents NOT INVOLVING INJURY, i.e. chemical spills, property damage, near misses or environmental incidents, contact Occupational Safety and Health Services at 487-2118, during normal working hours and then fill out the required incident report form. At all other times, call Public Safety from a campus phone at 7-2216.

Emergency Phone Numbers

	<u>Campus Phone</u>	<u>Outside MTU</u>
Emergencies:	9-1-1	
Houghton Fire Department:	8-482-1234	482-1234
Houghton Police:	8-482-2121	482-2121
Portage View Hospital Emergency:	8-487-7800	487-7800
National Poison Control Center:	8-1-800-562-9781	1-800-562-9781

Important Phone numbers:

MTU Occupational Safety and Health Services:	7-2118	487-2118
MTU Public Safety (non-emergency):	7-2216	487-2216
MTU Central Heating Plant:	7-2707	487-2707
MTU Department of Chemical Engineering:	7-3132	487-3132
Dave Caspary - Manager of Dept. Labs:	7-2022	487-2022

EMERGENCY RESPONSE

Time is essential when an accident or emergency occurs — a few seconds can make the difference between life and death. All departmental personnel should be familiar with emergency response procedures prior to the occurrence of an accident.

General Emergency Procedure

- Dial 9-1-1 on any campus phone.
- Report nature and location of accident, and identify yourself.
- Emergency personnel will be dispatched.
- Assist emergency personnel in locating accident.
- Submit an incident report (see Appendix A)

Evacuation Procedure

- All personnel are required to evacuate the building if the fire alarm sounds.
- Emergency exit stairs are found on both ends of the building hallways. There are three exits from the Chemical Sciences and Engineering building. These are 1) at the south end of the building on the first floor, 2) between the first and basement levels at the northeast corner stairwell of the building, and 3) in the middle of the hallway on the first floor. The loading dock area is not an emergency exit.

DO NOT USE THE ELEVATOR AS AN EVACUATION ROUTE.

Emergency exits are denoted by lighted exit signs posted on the ceilings.

- Quickly, but calmly, use the emergency exits to vacate the building.
- After leaving the building move at least 100 feet away.
- Do not re-enter the building until given the “all clear” by a Public Safety Officer.

Fires

- Use the safety shower to extinguish a clothing fire.
- Shut down equipment, if possible and if time permits.
- Use the appropriate fire extinguisher (see the section under Safety Equipment) to put out fire if this can be done without endangering yourself.
- Evacuate laboratory immediately and safely.
- Pull the fire alarm located at the ends of each hallway.
- Evacuate the building using the above evacuation procedure.
- Dial 9-1-1 on any campus phone.

Smoke

- If smoke is visible in the hallway or laboratory, and it is not obvious where it is coming from, DO NOT INVESTIGATE!
- Pull a fire alarm located at either end of the hallway and evacuate the building.
- Call 9-1-1 on a campus phone.

Chemical Spills See the detailed discussion in the Chemicals Safety section of this manual.

MTU Safety and Environmental Policy

The Safety Policy of Michigan Technological University is based on the firm conviction that accidents which cause personal injury or damage to property or the environment can be prevented. No phase of University business or operation is of greater importance than the safety of our students, faculty, staff, and visitors, and protection of the environment.

Michigan Technological University will provide and maintain a safe and healthy environment at all locations and will establish operating practices designed to assure the safety of all.

Each student, faculty, and staff is responsible for their individual safety performance and for protection of the environment. Each instructor/supervisor also has the responsibility to create a climate of safety and environmental awareness. Safety and environmental protection must be an integral part of every job. It is the responsibility of all to comply with safety rules and to work in such a manner as to prevent injuries to themselves, others and damage to the environment.

The prevention of accidents and the protection of the environment is in the best interest of all. Only through constant mutual effort and cooperation can we achieve these goals.

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1. INTRODUCTION

This safety manual is designed as a reference for all personnel in the Department of Chemical Engineering at Michigan Technological University. All personnel, including faculty, staff, and graduate students, must have a copy of this manual and must adhere to the safety principles within. In addition, each employee is expected to develop safe personal habits aimed at reduction of risk to themselves and coworkers.

The safety manual includes the necessary components of a Chemical Hygiene Plan (CHP). A CHP is defined by Michigan OSHA as a written program which sets forth procedures, and describes equipment, personal protective equipment and work practices that minimize exposure to health hazards presented by hazardous chemicals used in that particular workplace. Components of the CHP must include standard operating procedures for safety and health, criteria for the implementation of control measures, measures to ensure proper operation of engineering controls, provisions for training and information dissemination, permitting requirements, provisions for medical consultation, designation of responsible personnel, and identification of particularly hazardous substances.

This manual is also designed to meet the requirements of the following regulations:

- MI-OSHA 325.70101: Hazardous Chemicals in Laboratories

- MI-OSHA 325.70106: Chemical Hygiene Plan

- OSHA 1910.1450: Occupational Exposure to Hazardous Chemicals in Laboratories

- OSHA 1910.1200: Hazard Communication

This manual is a living document, and, as such, will change regularly as procedures and policies are updated and improved. It will be reviewed annually by the department. Suggestions on improvements are always welcome.

2. RESPONSIBILITIES

The protection of health and maintenance of safety constitute a moral obligation shared by everyone. Federal, state, local laws and regulations, and MTU policy make safety a legal requirement and an economic necessity as well. Laboratory safety, therefore, is not a purely voluntary function; it requires mandatory safety rules and programs and a commitment to them. A sound safety organization that is respected by all requires the whole-hearted participation of laboratory administrators, employees, faculty, and students.

The ultimate responsibility for safety within any institution lies with its chief executive officer or president. That individual must provide leadership to ensure that an effective safety program is in place so that all institutional officials will demonstrate a sincere and continuing interest in the program. Even a well-conceived safety program is apt to be treated casually by the workers if it is neglected by top management. Initiative and support for good safety programs, like most other institutional plans, usually come from the top down.

Although the responsibility for safety in a department or other administrative unit lies with its director or chair, the responsibility for the delineation of the appropriate safety procedures and the instruction of those who will carry out the operation lie with the project manager, principle investigator, or supervising faculty member. The responsibility for safety during the execution of an operation lies with those technicians, students, and other workers who actually perform that operation.

Safety is a requirement for employment. Thus, failure to follow the proper safety rules and procedures may result in one or more of the following: termination of employment, disciplinary action, expulsion from school, or closure of a research laboratory.

All faculty, managers and supervisors must:

- Integrate safety, health, and environmental protection into the daily activities of students, employees, and any other persons they supervise.
- Provide training and information to students, employees, and all others they supervise as requested by department administration and as required under University programs and policies.
- Review new equipment and procedures for recognized safety, health, and environmental hazards and take appropriate precautions before they are used or implemented.
- Investigate all incidents resulting in injury or property damage and report them to their department administrator and Occupational Safety and Health Services, OSHS. Close calls must also be investigated and reported if they are found to have had the potential for personal injury or property damage. All employee fatalities must be reported immediately to OSHS regardless of cause.
- Enforce safety rules and review work areas daily.
- Maintain a written record of the content of each training session and the identification of the trainer and all attendees.

RESPONSIBILITIES (cont'd)

Each student and every employee is responsible for the safety of their own actions, both for themselves and for their coworkers. They are also responsible for attending all training and informational meetings as requested, following proper work procedures, wearing assigned or required personal protective equipment, and reporting all hazardous conditions and incidents to their supervisor, instructor, or other applicable person. Employees are also expected to participate in the development of safe work procedures and methods of protecting the environment through their involvement with safety committees or other means of providing feedback to the University.

3. GENERAL SAFETY RULES - Specific rules will vary by location.

Unsafe Acts - The following unsafe acts are not allowed:

1. Alcoholic beverages, narcotics, hallucinogenic and other illegal drugs are not permitted on departmental property. Reporting to work under the influence of any of these substances is not allowed.
2. Firearms are not permitted on departmental property.
3. Horseplay, fighting and running are not permitted on departmental property.
4. Machinery and moving equipment must not be operated without the proper safety guards in place.
5. Only properly trained and authorized personnel are permitted to operate machines and equipment.
6. Eating, drinking, chewing gum, and use of tobacco products is not allowed in departmental laboratories.
7. Working alone in laboratories during off-hours (5 pm to 8 am, on weekends, or on holidays) is discouraged. During these hours, assistance during an emergency would not be readily available.

Personal Protective Equipment - The following general rules apply to personal protective equipment. Specific requirements are provided for specific laboratories.

1. All personnel must wear appropriate ANSI Z-87.1 eye protection devices in designated areas.
2. All personnel must wear hard hats in designated areas.
3. All personnel must wear the specified personal protective equipment when working with corrosive, toxic, hot, or other hazardous materials.
4. Any individual sustaining an injury on departmental property must report it promptly to the Chair of the Department of Chemical Engineering.

Other Rules

1. Laboratory floors must be kept dry, clean, and uncluttered at all times. Any spills should be cleaned up immediately using proscribed procedures and disposed of in an environmentally safe manner.
2. All laboratory personnel, including faculty, staff, students and all others involved with laboratory activities, are expected to be familiar with the hazards of all of the chemicals used in the laboratory and with the coding system used to label containers and pipelines.

Reporting

1. All accidents or incidents involving loss of MTU property must be reported to the Department Chair and a report must be filed with the MTU Office of Occupational Safety and Health Services.
2. Unsafe acts or conditions observed by any person on departmental property must be reported promptly to the Department Chair.

4. CHEMICAL HYGIENE OFFICER

The chemical hygiene officer will be a faculty or staff member from the Department of Chemical Engineering who is qualified by training or experience to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan.

The designated person will have a one year term of office (September thru August) and will be recommended by the Chemical Engineering Space and Safety Committee and appointed by the Department Chair.

The responsibilities of the Chemical Hygiene Officer (CHO) are:

- Coordinate and update the department Chemical Hygiene Plan annually.
- Act as a technical resource for questions regarding the Chemical Hygiene Plan and other issues related to lab safety.
- Meet with the Space and Safety Committee on a required basis on issues related to the Chemical Hygiene Plan.
- Work with the MTU Occupational Safety and Health Services to implement the Chemical Hygiene Plan.

It is not the responsibility of the Chemical Hygiene Officer to insure that the Chemical Hygiene Plan is working, this is the responsibility of the Space and Safety Committee, and the affected employees and students.

5. REVIEW AND EVALUATION OF SAFETY MANUAL

This Safety Manual must be reviewed and updated annually by the department and approved by the faculty and staff. Updates must normally be submitted to the faculty and staff in August for approval in September. However, updates can be done at any time.

6. LABORATORY INSPECTIONS

The checklist provided on the next two pages is the current inspection checklist. The checklist is updated annually, so the actual checklist used each year might differ somewhat from the one shown in this manual.

All laboratories must be inspected on a continuing basis with an audit inspection by an outside team at least once per year. All faculty must participate in the audit inspection process.

The Chemical Hygiene Officer, in consultation with the Manager of Laboratory Facilities and the Chair of the Department, may select laboratories for unannounced inspections. Priority will be given to laboratories with unacceptable previous inspections. The Chemical Hygiene Officer and the Manager of Laboratory Facilities will perform these inspections.

The audit or unannounced inspection results must be communicated, either verbally or in writing, to the laboratory owner within 1-day of the inspection. A full written inspection report must be provided to the laboratory owner within one week of the inspection.

The laboratory owner is encouraged to provide a written response to the audit or unannounced inspection. This must be done within one month of the inspection. This response will be filed with the inspection report.

A copy of all laboratory inspections will be maintained in the Chemical Engineering Office, and will be available for review by students, faculty and staff.

**MTU Department of Chemical Engineering
2008 Laboratory Safety Inspection Checklist**

Room Number: _____

Laboratory Supervisor: _____

Inspector: _____

Date: _____

Y = Yes N = No N/A = Not Applicable

A. Emergency

- | | | Y | N | N/A | |
|---|--|--------------------------|--------------------------|--------------------------|-----------|
| 1. Completed emergency information labels posted outside room | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 2. Exits not blocked | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Mandatory |
| 3. Window on laboratory door not covered | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 4. Emergency Exit route posted on inside of door | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 5. Fire Extinguisher: | Available within laboratory | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Clearly visible | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Not blocked | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Mandatory |
| | Annual inspection is up-to-date | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Correct for flammables present | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 6. Safety shower: | Available within laboratory | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Clearly visible | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Not blocked | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Mandatory |
| | Annual inspection is up-to-date | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 7. Eye wash: | Available within laboratory | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Clearly visible | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Not blocked | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Mandatory |
| | Annual inspection is up-to-date | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 8. Spill kits: | Available within laboratory if chemicals present | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Clearly visible | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| | Not blocked | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Mandatory |
| | Appropriate for chemicals present (includes mercury) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |

B. Housekeeping

- | | | | | |
|--|--------------------------|--------------------------|--------------------------|-----------|
| 1. Counters and floor clear of clutter | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Mandatory |
| 2. No food or evidence for food | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |

C. Compressed Gas

- | | | | |
|---|--------------------------|--------------------------|--------------------------|
| 1. Manual shutoff valves provided at all points of supply and use | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Corrosive gases stored no more than 6-months | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. All cylinders secured in place | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Pressure gauges in place | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

D. Mechanical Guarding

- | | | | |
|---|--------------------------|--------------------------|--------------------------|
| 1. Machine guarding in place | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Sharps disposal container available if hypodermic needles present in lab | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

E. Electrical

- | | | | | |
|---|--------------------------|--------------------------|--------------------------|-----------|
| 1. Electrical cords - not pinched, broken, cracked, or covered up | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Mandatory |
| 2. Circuits feeding potentially wet areas protected by GFCI | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 3. No exposed and energized electrical parts | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 4. Electrical panels are not blocked | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 5. Electrical panels labeled, even when not in service | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |

Laboratory Safety Inspection Checklist, p. 2

Lab No. _____

F. Ventilation

1. Laboratory hood sash is in working order - not stuck, broken, or removed
2. Equipment or materials do not obstruct air flow
3. Hood interior is clean, uncluttered, and not used as storage
4. Air flow rate is posted or flow gauge is present (between 80 - 120 fpm)
5. Air flow indicator on hood shows positive indication of hood function

Y	N	N/A
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

G. Personal Protective Equipment

1. Appropriate safety eye wear is worn
2. Appropriate shoes worn
3. Necessary PPE available

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory

H. Chemical Storage

1. Chemicals in open kept to a minimum
2. Flammable/combustible liquids stored in safety cans or flam. stg. cabinets
3. Flammable storage cabinets grounded
4. Incompatible chemicals, i.e. acids and bases, stored separately
5. Chemical containers are properly labeled
6. Chemical storage cabinets labeled

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

I. Chemical Waste Management

1. Chemical wastes stored in proper containers and location
2. All chemical wastes in labeled containers
3. All chemical wastes in compatible groups
4. Chemical waste disposal done regularly

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

J. Hazard Communication

1. MSDS sheets available for all non-R&D chemicals in lab
2. Safety Manual accessible
3. Emergency response phone numbers permanently marked on the phone
4. Chemical inventory is up-to-date and available
5. Standard operating procedures (SOP) are available

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mandatory

K. Glassware

1. Properly stored
2. Chipped, broken, or scratched glassware is disposed of
3. Broken glass container provided

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

L. Drying Ovens

1. JSA's for use are on file and followed.
2. A logbook is used to document use.
3. Direct-heated ovens are not used to dry flammables.
4. Mercury thermometers are not used in ovens.
5. Ovens used to dry materials that off-gas toxic or noxious vapors are located in a hood.

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

M. Compared to last inspection

☐ Improved ☐ About the same ☐ Conditions are worse

All items with a NO response are NOT in compliance.

Mandatory items must be in compliance for every inspection – failure to comply might result in immediate laboratory closure.

All other items must be corrected before the next inspection. These items will become mandatory for the next inspection.

Provide specifics on all items marked “no” above either in the space below or on an attached separate piece of paper. Also list special hazards or conditions not covered on this form.

Mandatory Items:	In compliance <input type="checkbox"/>	Not in Compliance <input type="checkbox"/>
-------------------------	---	---

Signatures of Inspectors: _____ Date: _____

Signature of Lab Supervisor(s): _____ Date: _____

Signature of Department Chair: _____ Date: _____

Feb, 2008

7. STANDARD OPERATING PROCEDURES

Standard operating procedures (SOPs) must be developed for operations involving the use of toxic, flammable, or reactive chemicals, or for operations involving physical hazards such as pressurized gases, increased temperatures, lasers, ionizing radiation, electrical shock exposures, or for any other hazards which might present a danger. An SOP must be developed for any new operations, substantial changes in operations that have an existing SOP in place, or for operations for which an SOP does not currently exist.

The SOP must include the start-up procedure, normal run-time procedure, normal shut-down procedure, and the emergency shutdown procedure. Each step in the procedure must identify the potential hazards, recommend an appropriate safety procedure, and list the personal protective equipment (PPE) required.

The SOP should also summarize the overall hazards encountered, the chemicals used in the procedure, the location of safety equipment, and the PPE required.

To facilitate development of the SOPs, a Job Safety Assessment (JSA) form has been developed for use by the department. The JSA form is available as a computer template file, in both Microsoft Word and WordPerfect formats. Check with the CHO for availability. The JSA template form is shown following this section.

The purpose of the Job Safety Assessment (JSA) form is to identify hazards in a laboratory procedure and to provide a method to control these hazards safely. A **hazard** is defined as “a chemical or physical condition that has the potential for causing damage to people, property, or the environment.” Accidents occur when control of a particular hazard is lost. For instance, the chemical aniline has a toxic hazard via skin absorption. An accident occurs if the chemical is spilled (loss of control of containment) on the skin of a person. The toxic hazard due to aniline exists as long as aniline is present in the laboratory – the JSA should identify this hazard and provide control methods to prevent this hazard from becoming an accident.

The JSA is a structured method used to identify hazards and their control. The JSA procedure is best implemented prior to construction and operation of a laboratory experiment. This insures that the changes and improvements identified during the JSA procedure are implemented in the final construction – changes are more difficult as the construction proceeds.

The procedure for the JSA is as follows:

1. The person constructing or operating the laboratory apparatus completes the JSA form.
2. A committee reviews the JSA and makes suggestions. This committee must have experience in the JSA procedure and safety in general. For a graduate student project, this committee should consist of the graduate student, the student's advisor, and two additional faculty or staff members.
3. The JSA is revised based on the suggestions. If the JSA revisions are substantial, an additional committee meeting might be necessary to insure that the changes were done

properly.

The JSA is very useful for developing a viable procedure to perform the experiment. A subsequent benefit is that the suggestions made by the committee dramatically improve the operability and success of the experiment.

The JSA document provided is form protected – you may only type in the fields shown.

Specific Detail on JSA

Page 1:

Purpose of Experiment / Equipment: Provide a few sentences here describing overall what you are attempting to do.

Personal Protective Equipment (PPE): This section should only list the PPE used during the entire experimental procedure – not all of the PPE. Specific PPE required for a single procedure step should be listed in the Procedures page. For instance, if the laboratory requires safety glasses at all times, then safety glasses should be checked here. However, if a chemical transfer step in the procedure requires a specific type of chemical glove, then the chemical glove should not be listed here, but only in the specific step on the procedures page.

Hazard Summary: Check here all the hazards that are expected to be encountered in this laboratory experiment, and list the single major source of the hazard. Do not list all of the sources of a hazard. For instance, under toxicity, if two toxic chemicals are used, then the most toxic chemical should be listed here.

Expected Operating Conditions: List the normal and maximum operating temperature and pressure.

Page 2:

Special Operating Conditions: Check all of the conditions that apply to your experiment. If any of these items are checked, the Manager of Laboratory Facilities must be consulted.

Available Safety Equipment: Describe the location of each of the items listed. If the item is not available or not required, state this in the space provided. Identify the location of the equipment on the laboratory floor plan.

Spill Response Supplies: Describe the location of each of the items listed. If the item is not available or not required, state this in the space provided. Identify the location of the spill supply on the laboratory floor plan.

Required Attachments: Provide the following required attachments:

1. Flow diagram of process or equipment. Provide a single page flow diagram with adequately labeled valves and other equipment pieces.
2. Laboratory floor plan. Provide a one page sketch of the laboratory layout, showing the location of the process discussed in this JSA, the location of other major equipment in the lab, and the location of safety equipment.
3. Equipment specifications. Provide detail on materials of construction, maximum pressure and temperature of operation, and so forth.
4. Material safety data sheets (MSDS). Provide MSD sheets for all chemicals, including reactants, products and any intermediate or side reaction chemicals that persist long enough to present a hazard.

Additional Attachments: Provide any additional attachments that may be important for the committee to review in order to assess the hazards of the process.

Page 3:

Chemicals Used: List all chemicals, including reactants, products, solvents and any intermediate or side reaction chemicals that persist long enough to present a hazard. Provide the NFPA ratings for health, flammability, stability and any special hazards ratings. Provide a list of incompatible chemicals that are present within the same laboratory or using in this experiment. Provide the hazardous waste code (see the Chemical Engineering Hazardous Waste Manual). If the chemical is regulated (see the Chemical Engineering Safety Manual) then check the box provided. Finally, list any personal protective equipment specific to this chemical, i.e. type of glove and glove material.

At the bottom of the chemical information page, specify the location of the MSDS library within the laboratory.

Page 4:

Chemical Reactions: List all chemical reactions that may occur, including side reactions and decompositions, if known. List the heat of reaction of each reaction, if known. You cannot type subscripts in the form field provided – write the chemical reactions using the names for the species with the correct stoichiometric coefficients.

Page 5:

The Safe Operation Procedures page is the most important part of the JSA form. In this part you will detail the steps for your experiment, identify the potential hazards and recommend the procedure to control the hazard and the personal protective equipment (PPE) required. Please attempt to be detailed and creative in identifying the hazards.

In the table column on Recommended Safety Procedure, do not include emergency response procedures here. You must focus on the procedures required to prevent an accident.

The specific sections here are:

Emergency Shutdown: List here the 2 or 3 steps required to shut-down the experiment during an emergency situation where you were required to leave the laboratory (such as a fire alarm in the building). It is not always appropriate to turn everything off – it is safer to leave cooling water running than to shut it off.

Start-up Procedure: List here all the steps required to prepare the equipment for operation. This includes proper valve configuration, charging of reactants, filling of vessels, preparation of titration equipment and materials, etc.

Run-time Procedure: List here all the normal operation steps.

Shutdown Procedure: List here all the steps to normally stop the operation of the equipment. This would detail the valves to be closed or opened (and the order of closure), motors to be turned off or on, etc.

Cleanup / Waste Disposal: List here all the steps required to complete the experiment and return the equipment for safe, unattended storage in the laboratory. Detail the vessels to be emptied, the hoses or pipes to be flushed, the equipment to be turned off, and the steps required to clean the equipment. Also list here the steps required to dispose of any waste that is generated by this experiment.

Job Safety Assessment Form
Department of Chemical Engineering
Michigan Technological University

Equipment Name:	JSA Author:
Room Number/Building:	Faculty Supervisor:
Revision #:	Revision Date:

Purpose of Experiment / Equipment: Briefly describe what this experiment is designed to achieve and the types of data collected.

--

Personal Protective Equipment (PPE) – Check all PPE worn during the entire experiment. Do not list these in the procedure section.

<input type="checkbox"/> Long Pants	<input type="checkbox"/> Safety Glasses	<input type="checkbox"/> Hard Hat	<input type="checkbox"/> Apron
<input type="checkbox"/> Long Sleeves	<input type="checkbox"/> Splash Goggles	<input type="checkbox"/> Insulated Gloves	<input type="checkbox"/> Ear Protection
<input type="checkbox"/> Non-porous Shoes	<input type="checkbox"/> Face Shield	<input type="checkbox"/> Chemical Gloves	<input type="checkbox"/> Other:

Hazard Summary – Check all general hazards that are likely to be encountered during this experiment and list the major source of the hazard.

Hazard	Major Source of Hazard
<input type="checkbox"/> Toxicity	
<input type="checkbox"/> Fire/Flammability	
<input type="checkbox"/> Reactivity	
<input type="checkbox"/> Pressure Hazard	
<input type="checkbox"/> Electrical Shock	
<input type="checkbox"/> Mechanical Hazard	
<input type="checkbox"/> Hot Surfaces/ High Temp > 150 F	
<input type="checkbox"/> Biohazard	
<input type="checkbox"/> Laser Radiation	
<input type="checkbox"/> Ionizing radiation	
<input type="checkbox"/> Other: _____	
<input type="checkbox"/> Other: _____	

Expected Operating Conditions –

Temperature	Pressure
Normal:	Normal:
Minimum:	Minimum:
Maximum:	Maximum:

Special Operating Conditions - Check all that apply and consult department Safety Manual.

Unattended Operation: <input type="checkbox"/>	Drying Oven: <input type="checkbox"/>
Regulated Chemicals: <input type="checkbox"/>	Class 3b or 4 Lasers: <input type="checkbox"/>
Pressures Exceeding 35 atm (515 psia) or Equipment Specifications: <input type="checkbox"/>	
Temperatures Exceeding 1000°C or Equipment Specifications: <input type="checkbox"/>	

Available Safety Equipment – Provide the location of each item shown below. Show the location of this equipment on the attached floor plan. If not available, type “NA” in the field.

Item	Location
Fire Extinguisher:	
Eyewash:	
Safety Shower:	
Telephone:	
First Aid Kit:	
Other:	
Other:	

Spill Response Supplies - Provide the location of each item shown below. Show the location of this equipment on the attached floor plan. If not available, type “NA” in the field.

Item	Location
Spill Kit:	
Floor-Dri:	
Spill Dikes:	
Sodium Bicarbonate:	
Drain Plugs:	
Spill Pillows:	
Mercury Spill Kit:	
Other:	
Other:	

Required Attachments:

<input type="checkbox"/> Diagram of process or equipment Label all valves and identify all equipment for reference in procedure.
<input type="checkbox"/> Laboratory Floor Plan Identify the location of your experiment and all safety and spill response equipment.
<input type="checkbox"/> Equipment Specifications Include materials of construction, maximum temperature and pressure, standard operating values, and any other specifications important to the safe operation.
<input type="checkbox"/> Material Safety Data Sheets (MSDS) Include for all reactants, products and any intermediate or other chemicals which may occur.

Additional Attachments: As necessary.

<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>

Chemical Information Page

Fill in as much data below as available. If data are not available, leave the field blank.
List all chemicals, including reactants, products, intermediates, solvents, and any others used.

Chemical Properties and Hazards

Chemical Name	Physical State S, L, G	NFPA Ratings*				Incompatible Chemicals List chemicals present within the laboratory, and any others that may come in contact.	Flash Point Temp.	Flammability Limits	
		H	F	S	Sp.			LFL	UFL

*NFPA Ratings: **H** – Health, **F** – Flammability, **S** – Stability, **Sp.** – Special

Chemical Toxicology, Regulation and Disposal: List the same chemicals that appear above, in the same order.

Chemical Name	Toxicology			Hazardous Waste Number [#]	Regulated? See Safety Manual	Personal Protective Equipment Specific to this Chemical
	TWA	PEL	Other			
					<input type="checkbox"/>	
					<input type="checkbox"/>	
					<input type="checkbox"/>	
					<input type="checkbox"/>	
					<input type="checkbox"/>	
					<input type="checkbox"/>	
					<input type="checkbox"/>	
					<input type="checkbox"/>	

[#]See Chemical Engineering Hazardous Waste Manual.

Chemical Reactions: Provide details below on any chemical reaction(s) that occur in your process. Please show the species involved, the stoichiometry and the heat of reaction, if available. Also list side reactions and any other reactions that may impact safety. You cannot type subscripts in the form field provided – use the names for the species and the stoichiometric coefficients.

Job Safety Assessment Form
Safe Operating Procedures Page

Sequence of Steps	Potential Hazards	Procedure to Control Hazard	PPE or Equipment Required
Emergency Shutdown			
Start-up Procedure			
Run Time Procedure			
Shutdown Procedure			
Cleanup / Waste Disposal			

8. CONTROL MEASURES

Chemicals - See the section on Chemical Safety for control measures.

Electrical - See the section on electrical hazards in the Equipment Section.

Lasers - See the section on Laser Safety.

Radiation Hazards - See the section on Radiation Safety.

Thermal hazards - see the section on Steam Lines and Condensate Lines in the Equipment Safety Section.

9. TRAINING

All employees of Michigan Technological University are required, by law, to receive training to understand the following:

1. The location and contents of the department Safety Manual.
2. The Permissible Exposure Levels (PELs) and/or the Threshold Limit Values (TLVs) for commonly used hazardous chemicals in the workplace. You must also know where to obtain information on the PEL's and TLV's of other chemicals.
3. The signs and symptoms associated with exposure to the hazardous chemicals in the workplace.
4. The locations of reference sources on the safe handling, storage and disposal of hazardous chemicals in the workplace.
5. Knowledge and skills necessary for the detection of the presence of hazardous chemicals in the workplace.
6. Knowledge of the physical and health hazards associated with the hazardous chemicals used in the workplace.
7. Measures used to protect oneself from exposures to hazardous chemicals, including safe work practices, emergency procedures, and the use of personal protective equipment.

This instruction is designed to meet the following regulatory requirements:

MI 325.70101: Hazardous Work in Laboratories

MI 325.70106: Chemical Hygiene Plan

OSHA 1910.1450: Occupational Exposure to Hazardous Chemical in Laboratories

OSHA 1910.1200: Hazard Communication

All new graduate students are required to take CM5310 Laboratory Safety, which is offered during the Fall semester. New faculty and staff, and others who have not received this training, are also required to take this training.

10. PRIOR APPROVAL FOR HAZARDOUS OPERATIONS

The following operations will require special approval by either the Chemical Hygiene Officer (CHO) or the Manager of Laboratory Facilities prior to operation. This is in addition to the Standard Operating Procedure (SOP) and safety review that must be completed.

- Use or storage of any regulated chemicals (see list in Chemical Safety section).
- Temperatures exceeding 1000°C, or any temperatures exceeding equipment design or specifications.
- Pressures exceeding 35 atm (515 psi), or any pressures exceeding equipment design or specifications.
- Class 3 or Class 4 lasers.

The above values are only guidelines for special approval - it is possible for a significant hazard to exist at other values. If in doubt, please check with the CHO or Manager of Laboratory Facilities.

11. ADDITIONAL PROTECTION FOR PARTICULARLY HAZARDOUS SUBSTANCES OR AGENTS

Particularly hazardous substances are those that have moderate chronic or high acute toxicity, high reactivity, or may decompose suddenly upon exposure to heat or shock. This also includes carcinogens and reproductive toxins.

These materials will require prior approval by the Chemical Hygiene Officer (CHO), or by the Manager of Laboratory Facilities.

Specific consideration for these materials must include:

- The establishment of a designated area or areas indicating the physical limits of exposure to these substances.
- The proper use of containment devices, such as hoods, glove boxes, etc.
- Procedures for the safe removal of contaminated waste.
- Decontamination procedures.

In addition, one or more of the following may be required:

- Air monitoring
- Medical examinations
- Additional specific training
- Additional personal protective equipment
- Additional emergency response equipment
- Any other steps required to insure the safe handling, use, and disposal of these materials or agents.

12. MEDICAL CONSULTATION AND EXAMINATIONS

Medical examinations are required for the following:

- Personnel using respiratory protection.
- Documented exposures above established action levels (including noise, lasers, ionizing radiation, etc), or for airborne concentrations above one-half of the PEL, TLV, or other recognized exposure limit.
- Personnel exhibiting signs or symptoms consistent with exposure to the chemicals or hazards with which they are working.
- Personnel exposed to hazardous chemicals or hazards as a result of a spill, leak, or explosion.

Medical examinations may be requested by the Laboratory Supervisor or Instructor.

For examinations resulting from exposures to OSHA regulated substances, the examination frequency will be the period set within the OSHA standard. For examinations resulting from potential overexposure to hazardous substances, the examination frequency will be determined by the attending physician. All other examinations required (including PPE usage) will be annual, unless otherwise specified by the attending physician.

The following information will be provided to the employee by the examining physician:

- The identity of the hazardous chemical(s), or hazardous agent, which the employee has been or may be exposed.
- A description of the conditions under which the exposure occurred, including quantitative exposure data, if available.
- A description of the signs and symptoms of exposure that the employee is experiencing.

The employee shall also obtain a written opinion from the examining physician containing the following:

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

Medical examinations resulting from workplace exposures must be provided to employees without charge.

13. UNATTENDED OPERATION

Unattended operation of equipment in the laboratory is discouraged since hazardous situations might develop that would normally not present a significant problem if someone were in the laboratory to correct the problem. This includes equipment leaks, failed bearings, overheated equipment, hose failures, and so forth. Furthermore, power or water failures might initiate hazardous situations.

Some equipment may operate with minimal hazard in unattended mode. A form is provided on the following page that must be completed and posted on the laboratory door for unattended operation. This form provides emergency response information, utility information, and contact information in the event of a problem.

14. GRADUATE STUDENT DEGREE COMPLETION

Upon completion of graduate degree requirements, an exit form shown in Appendix D must be completed and signed by the Manager of Laboratory Facilities and the Department Chair. This form must be submitted at the time your oral examination scheduling form is submitted. The purpose of this form is to insure that all chemicals have been reassigned or disposed, chemical wastes have been properly disposed, and loaned equipment has been returned.

Michigan Tech University
Department of Chemical Engineering

Unattended Equipment/Experiment Operation Notice

This form is to be filled out and posted on the outside of the lab door whenever an experiment is left running at night or over the weekend if that experiment could become hazardous during unattended operation.

Room Number _____

Building _____

Start Date _____

End Date _____

(This notice will automatically terminate one week from start date unless an end date is specified.)

IN CASE OF EMERGENCY, PLEASE CALL:

Name _____

Name _____

Phone _____

Phone _____

If possible, THE UTILITIES CHECKED BELOW SHOULD BE SHUT OFF IF AN EMERGENCY OCCURS:

_____ Electricity
_____ Steam
_____ Vacuum

_____ Water
_____ Natural Gas
_____ Air

_____ Bottled Gas
Type _____
Location _____

The electrical breakers for this equipment are located in _____

and labeled _____

THE FOLLOWING UTILITIES SHOULD **NOT** BE SHUT DOWN:

The following special precautions should be taken:

Signature

15. FUNDAMENTALS

The primary hazards associated with chemical usage are chemical exposure hazards, flammability hazards and reactivity hazards. Chemical exposure hazards are determined using Threshold Limit Values (TLV's) and Permissible Exposure Levels (PEL's). Flammability hazards are determined using flashpoints for liquids, and upper and lower flammability limits. Reactivity hazards are difficult to characterize and are beyond the scope of this document.

For additional information on these concepts, refer to:

1. *Documentation of the Threshold Limit Values and Biological Exposure Indices*, American Conference of Governmental Industrial Hygienists, Inc., Cincinnati, OH. This document is updated annually.
2. N. Irving Sax, *Dangerous Properties of Industrial Materials*, 10th ed., Van Nostrand Reinhold, NY, 1999.
3. *Prudent Practices in the Laboratory*, National Academy Press, 1995.
4. *NIOSH Pocket Guide to Chemical Hazards*, U.S. Department of Health and Human Services, 2005. Also available on CD-ROM and on-line at www.cdc.gov/niosh/npg/

Toxicity Hazards

The *toxicity* of a chemical or physical agent is a property of the agent describing its effect on biological organisms. The *toxic hazard* is the likelihood of damage to biological organisms based on exposure resulting from transport and other physical factors of usage. The toxic hazard of a substance can be reduced by the application of appropriate industrial hygiene techniques. The toxicity, however, cannot be changed.

Threshold Limit Values (TLV): The American Conference of Governmental Industrial Hygienists (ACGIH) has established threshold doses, called threshold limit values (TLVs), for a large number of chemical agents. The TLV refers to airborne concentrations that correspond to conditions under which no adverse effects are normally expected during a worker's lifetime. The exposure occurs only during normal working hours, eight hours per day and five days per week. There are several types of TLVs:

TLV-TWA: Time weighted average for a normal 8-hour workday or 40 hour workweek, to which nearly all workers can be exposed, day after day, without adverse effects. Excursions above the limit are allowed if compensated by excursions below the limit.

TLV-STEL: Short-term exposure limit. The maximum concentration to which workers can be exposed for a period of up to 15-minutes continuously without suffering (1) intolerable irritation, (2) chronic or irreversible tissue damage, (3) narcosis of sufficient degree to increase accident proneness, impair self rescue, or materially reduce worker efficiency, provided that no

FUNDAMENTALS (cont'd)

more than four excursions per day are permitted, with at least 60-minutes between exposure periods, and provided that the daily TLV-TWA is not exceeded.

TLV-C: Ceiling limit. The concentration which should not be exceeded, even instantaneously.

Permissible Exposure Level (PEL): Same as TLV-TWA, but defined by OSHA. The airborne concentrations are expressed in parts per million by volume (ppm).

	TLV-TWA	PEL
	ppm	ppm
Acetic acid:	10	10
Acetone:	750	750
Ammonia:	25	25
Bromine:	0.1	0.1
Carbon monoxide:	50	35
Ethyl ether:	400	400
Heptane:	400	400
Isopropyl alcohol:	400	400
Isopropyl ether:	250	250
Methyl alcohol:	200	200
Methylene chloride:	50	50
Methyl ethyl ketone:	200	200
Napthalene:	10	10
Nitric acid:	2	2
Pentane:	600	600
Phosgene:	0.1	0.1
Turpentine:	100	100
Xylene:	100	100

Flammability Hazards

A fire or explosion requires a combination of fuel, oxidant and an ignition source. Ignition sources are so common that for all practical purposes, a flammable mixture, i.e. fuel + oxidant, can be expected to ignite.

THE PRIMARY DEFENSE AGAINST FIRES AND EXPLOSIONS IS TO PREVENT THE EXISTENCE OF FLAMMABLE MIXTURES.

Flashpoint: The lowest temperature at which a liquid produces adequate vapor to form an ignitable mixture with air. At the flash point the vapor will burn (flash), but only briefly; inadequate vapor is produced to maintain combustion.

FUNDAMENTALS (cont'd)

THE LOWER THE FLASHPOINT, THE MORE FLAMMABLE THE LIQUID!

IF A LIQUID HAS A FLASHPOINT BELOW ROOM TEMPERATURE, THAT MEANS THAT FLAMMABLE VAPORS EXIST ABOVE THE LIQUID AS IT IS STORED!

In handling these materials, particular care must be taken to avoid ignition sources. See the section on Chemical Safety.

Firepoint: The lowest temperature at which a liquid produces adequate vapor to burn continuously.

Flammability Limits (LFL and UFL): Vapor-air mixtures will only ignite and burn over a well-specified range of compositions. The mixture will not burn if the composition is lower than the lower flammable limit (LFL); the mixture does not contain enough fuel for combustion (too lean). The mixture is also not combustible when the composition contains too much fuel (too rich); that is, when it is above the upper flammable limit (UFL). Above the UFL there is not enough oxygen for combustion. A mixture with air is only flammable when the composition is between the LFL and UFL. Limits are expressed as volume percent fuel in air.

A vapor mixture above the UFL should never be considered as a safe atmosphere for any purpose. If air is introduced into the vapor space, or the vapors escape the container and mix with air, a flammable mixture is highly probable with an explosion or fire hazard.

	Flashpoint (deg. F)	LFL Vol%	UFL Vol%
Acetone:	0.0	2.5	13
Benzene:	12.0	1.3	7.9
Butane:	-76	1.6	8.4
Carbon monoxide:	gas	12.5	74
Ethyl alcohol:	55	3.3	19
Ethyl ether:	-49	1.9	36
Gasoline:	-45	1.4	7.6
Hexane:	-15	1.1	7.5
Isopropyl alcohol:	53	2.0	12
Isopropyl ether:	0	1.4	7.9
Methane:	-306	5	15
Methyl alcohol:	54	6	36
Methyl ethyl ketone:	24	1.4	11.4
Pentane:	-40	1.5	7.8
Toluene:	40	1.2	7.1

FUNDAMENTALS (cont'd)

Reactivity Hazards

Chemicals may react very suddenly and without anticipation under the proper conditions. The reaction may release large amounts of heat and/or gases which may result in high pressures and temperatures in an apparatus. In addition, the reaction products may be toxic or flammable, creating an additional hazard. The consequence may be a fire, explosion, or release of toxic materials.

Sometimes a *runaway reaction* may occur. In a runaway reaction the heat generation in a material or process is greater than the heat removal. This results in heat accumulation and an increase in temperature. The increase in temperature results in a higher rate of heat generation. Some reactions will runaway at rates up to several hundred degrees Celsius per minute and with very high pressure rates. Sometimes the temperature during the runaway increases to the point that an unknown decomposition reaction occurs, with sometimes greater consequence than the original, known reaction.

Characterization of reactive chemistry is very difficult. Contact the Chemical Hygiene Officer (CHO) or Manager of Laboratory Facilities for assistance.

16. PERSONAL PROTECTION

Before doing work requiring use of personal protective equipment, all individuals must be trained to know when personal protective equipment is necessary, what type is necessary, how it must be worn, and what its limitations are. In addition, the employee must know its proper care, maintenance, useful life, disposal, and legal implications of use. In many cases more than one type of personal protective equipment will provide adequate protection.

See your supervisor / advisor / instructor about personal protective equipment.

Ear Protection

Exposure to high noise levels can cause hearing loss or impairment. It can create physical or psychological stress. There is no cure for noise-induced hearing loss, so the prevention of excessive noise exposure is the only way to avoid hearing damage. Specifically designed protection is required, depending on the type of noise encountered and auditory condition of the employee.

Preformed or molded earplugs should be individually fitted by a professional. Waxed cotton, foam, or fiberglass wool earplugs are self forming. When properly installed they work as well as most molded earplugs.

Plain cotton is ineffective as protection against noise.

Some earplugs are disposable, to be used one time and then thrown away. This type is available from Chem Stores: Bilsom #5048-08 (NRR =26), Moldex Pura-Fit #6800 (NRR = 31). The non-disposable type should be cleaned after each use for proper protection.

Earmuff type protection must make a perfect seal around the ear to be effective. Glasses, long sideburns, long hair, and facial movements, such as chewing, can reduce protection. Special equipment is available for use with glasses or beards.

The University Occupational Safety and Health Department has a device to measure sound levels and can assist in any noise-related problems.

All individuals exposed to noise exceeding 85 decibels continuous over an 8-hour period must participate in a hearing conservation program. Contact the University Occupational Safety and Health Department, 487-2118.

PERSONAL PROTECTION (cont'd)

Eye Protection

Suitable eye protection must be provided when there is a potential for injury to the eyes or face from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, potentially injurious light radiation or a combination of these. Eye protection must meet the following minimum requirements:

- A. Provide adequate protection against the particular hazards for which they are designed.
- B. Be reasonably comfortable when worn under the designated conditions.
- C. Fit snugly without interfering with the movements or vision of the wearer.
- D. Be durable.
- E. Be capable of being disinfected.
- F. Be kept clean and in good repair.

Glasses with sideshields are to be worn at all times in designated laboratory areas. Safety glasses must comply with ANSI Z87.1-1989. Chemical splash safety goggles must be worn when handling hazardous chemicals. Various styles are available from Chem Stores.

Contact lens usage in the laboratory is still a controversial subject. Most industrial firms now allow contact usage - but only with notification of supervision and with additional eye protection such as goggles. Please check with your laboratory instructor / supervisor.

Footwear

Proper footwear is required in laboratories to protect the feet against burns from chemicals, steam, and hot water.

All persons performing any operations with chemicals (including transportation); using steam or hot water; or operating mechanical equipment must meet the following footwear requirements:

- A. Non-porous shoes must be worn to prevent liquid penetration.
- B. High-top leather workboots are strongly recommended.
- C. The following footwear are not allowed:
 - 1. Porous leather or cloth shoes.
 - 2. Ventilated shoes.
 - 3. Sandals.
 - 4. High heeled shoes, greater than 1-inch in height.

PERSONAL PROTECTION (cont'd)

Gloves

Gloves protect the hands against chemical, mechanical, electrical and thermal hazards. A wide assortment of gloves are available:

- A. Insulated gloves are required to avoid burns when operating steam valves and when handling hot objects.
- B. Gloves are required to avoid contact with chemicals that can burn or penetrate the skin. The glove material must be compatible with the chemicals handled - check the table below, the MSDS, or the glove manufacturer. Chemical gloves must NOT be used for steam valves and hot objects; they can melt onto the skin and cause 2nd degree burns.

Gloves are available in Chem Stores or from Lab Safety Supply. An abbreviated compatibility table is shown below. A more detailed compatibility table is available in the Lab Safety Supply catalog.

CHEMICAL FAMILY	BUTYL RUBBER	NEOPRENE	PVC (VINYL)	NITRILE	NATURAL LATEX
Acetates	G	NR	NR	NR	NR
Acids, inorganic	G	E	E	E	E
Acids, organic	E	E	E	E	E
Acetonitrile, Acrylonitrile	G	E	G	S	E
Alcohols	E	E	NR	E	E
Aldehydes	E	G	NR	S*	NR
Amines	S	NR	NR	F	NR
Bases, inorganic	E	E	E	E	E
Ethers	G	F	NR	E	NR
Halogens (liquids)	G	NR	F	E	NR
Inks	G	E	E	S	F
Ketones	E	G	NR	NR	G
Nitro compounds (Nitrobenzene, Nitromethane)	G	NR	NR	NR	NR
Oleic Acid	E	E	F	E	NR
Phenols	E	E	NR	NR	G

PERSONAL PROTECTION (cont'd)

CHEMICAL FAMILY	BUTYL RUBBER	NEOPRENE	PVC (VINYL)	NITRILE	NATURAL LATEX
Quinones	NR	E	G	E	E
Solvents, Aliphatic	NR	NR	F	G	NR
Solvents, Aromatic	NR	NR	F	F	NR

*Not recommended for Acetaldehyde, use Butyl Rubber

S - Superior

E - Excellent

G - Good

F - Fair

NR - Not Recommended

Hardhats

A hardhat may be required in certain laboratories, particularly those with "high bay" construction. Hardhats provide protection from falling objects and from striking the head against pipes and equipment.

- A. Hardhats must not be painted, or covered with stickers which will hide any damage or cracking to the unit.
- B. Class B hardhats, which provide electric shock protection, are recommended.
- C. Hardhats must comply with ANSI Z89.1-1986.

Hardhats are available from Chem Stores.

Required Clothing

Any exposed skin represents a serious risk in the laboratory. Accidents involving skin exposures may occur due to chemical, thermal, electrical and mechanical contact or entanglement. Each situation must be evaluated for these possible exposures. In addition to any barriers, shields or guards, appropriate clothing must be worn to address the hazards. If any of these hazards are present, then an appropriate policy must be developed and enforced. Consider the following when developing a specific policy:

- A. Long pants should be required for all laboratory activities.
- B. If entanglement hazards are present (such as rotating lathes, drill presses, etc), long hair must be restrained, neckties, jewelry of any kind and loose clothing must be prohibited.

PERSONAL PROTECTION (cont'd)

- C. A long sleeve shirt, with the sleeves fully extended to the wrist, should be considered for incidental exposures. If the sleeves have buttons, they must be buttoned. Entanglement hazards due to rotating equipment may require the use of short-sleeved shirts.
- D. Potential exposure to flammables, caustics or irritants may require the use of fire or chemical resistant clothing or lab coats.
- E. Electrical hazards may require the use of special footwear or gloves and may prohibit the use of rings and watches.
- F. Welding, grinding, metal cutting and heat treating operations may also require special protective clothing.
- G. Refer to the Footwear section for information on foot exposures.

Respiratory Protection

All persons using respirators must notify MTU OSHS and meet all requirements of the MTU Respirator program. This respirator program includes respirator selection, medical evaluation, fit testing and training (OSHA 29CFR 1910.134 and Michigan State requirements). Contact MTU OSHA at 7-2118 for more details on meeting these requirements.

MTU students and employees have the potential for exposure to harmful air contaminants. Engineering controls, for example laboratory fume hoods, have been provided to eliminate or reduce exposures to safe levels. It is the responsibility of faculty, supervisors, and managers to utilize these existing engineering controls as well as administrative controls to keep air contaminant exposures below the Michigan Occupational Health permissible exposure limit, PEL, if it exists. Where existing engineering controls are not adequate, it is their responsibility to determine the feasibility of installing additional engineering and administrative controls, including substitution of less toxic materials, necessary to maintain exposures below the PEL. It is highly encouraged that these engineering and administrative control methods be utilized to keep air contaminant concentrations not only below the PEL, but as low as reasonably feasible and below the applicable ACGIH threshold limit value, especially where a PEL does not exist. Respirators shall only be used to achieve compliance with a PEL when it is not feasible to do so with engineering or administrative controls. When respirators are used by employees at MTU, their use is subject to the requirements of the MTU Respirator program and each request will be reviewed by Occupational Safety and Health Services.

Respirators shall be used in the following circumstances:

- A. When exposure levels exceed the permissible exposure level (PEL), during the time period necessary to install or implement feasible engineering and work practice controls.
- B. In most maintenance and repair activities and during those brief or intermittent operations where exposures exceed the PEL and engineering and work practice controls are not feasible or are not required.

PERSONAL PROTECTION (cont'd)

- C. In regulated areas, where all feasible engineering and work practice controls are not sufficient to reduce exposures to below the PEL.
- D. In emergencies.

In general, respirators should not be worn as part of normal operations. Respirators are used for emergency response, spill clean-up or hazard remediation only.

Many types of respirators are available - their selection and use are beyond the scope of this document. You must contact MTU OSHS at 7-2118 to meet the MTU Respirator program requirements for respirator selection.

Contact lenses may be worn with respirators.

In any situation where a respirator is necessary, the building ventilation systems must be operated in an emergency, non-recycle mode to prevent exposure to other building occupants. In the case of an emergency a building evacuation may be necessary. For special operations, the operations must be scheduled with MTU OSHA, MTU Energy Management and preferably be carried out on weekends or other periods when the building occupancy is low.

Dust Masks Dust masks are considered respirators and are covered by the MTU Respirator Program. Please contact OSHA at 7-2118 for details on this program, or see the MTU OSHS web page.

A dust mask should be worn when handling nuisance powdery solids - they prevent inhalation of airborne particulates. The dust mask must be suitable for the particular dust. The recommended type: single use, 2-strap type: 3M #8210, 8110 or 8710 available from Lab Safety Supply.

17. SAFETY EQUIPMENT

Safety equipment is installed in departmental facilities to assist workers should an accident occur. The installation, use and maintenance of this equipment is described here.

Telephones

All laboratories should have a telephone to allow for emergency response. This telephone should be readily accessible and must have the MTU emergency phone number posted on it. Emergency numbers are listed in the front of this document.

General Criteria for Eye Wash and Safety Shower Units

The general criteria for eye wash stations and safety showers units are described in ANSI Z358.1-1998. The temperature of the water is also important. If the temperature of the water is too high (over 100 degrees Fahrenheit) it may be harmful to the eyes and could even increase chemical interaction with the body. If the temperature is too cold it is very difficult to keep the eyes open due to the discomfort. The temperature of the water is recommended to be between 78 and 92 degrees Fahrenheit (25.5 and 33.3 degrees Celsius). The additional criteria are:

- (1) Initiation: one hand, one action. Once initiated, flow continues, leaving both hands free.
- (2) Location: Emergency eyewash and shower equipment shall be located on the same level as the hazard, have un-obstructed access, and require not more than 10 seconds to reach. Eyewashes must be positioned between 34 inches to 39 inches high. Shower heads must be approximately 82 inches high. The pull chain for shower activation must be no more than 67 inch high, and positioned no more than 23 inches off center from the shower head. The location must be clearly marked, well-lighted, and easily accessible, i.e. no obstacles, doorways, or turns.

Eye Wash Fountains

Use:

- Chemical contact with the eyes.

Operation:

- Depress lever on right hand side of fountain (water pressure should pop the caps off).
- Place eyes in contact with water stream for 15-20 minutes.
- Important that eye lids are kept open. A second person should assist in holding the eye lids open.
- Contact lenses must be removed.

Maintenance:

- Eye wash stations must be activated weekly to insure proper operation and to flush out potentially stagnant or rust-colored water.
- Eye wash stations must be tested annually for water flow. This is normally done by university personnel, but it is the responsibility of the laboratory owner to insure

SAFETY EQUIPMENT (cont'd)

that this occurs.

- Water flow must be at least 4 gpm, per ANSI Z358.1-1998.
- Water must continue to flow once handle is released.
- Water jets must be high enough to cross each other.
- Keep eye wash station clear of obstructions.
- Caps on eyewash jets must remain in place until the eyewash is activated.

Safety Showers

All laboratories using hazardous chemicals, or where the potential exists for a clothing fire, must have ready access to a safety shower.

Use:

- Splashed or spilled chemicals onto clothing or oneself.
- Clothing fires.

Operation:

- Pull chain suspended beside the shower.
- The quick acting valve will deluge the victim with water.
- All clothing contaminated with chemical must be removed.

Maintenance:

- Safety shower must be operated at least monthly to insure proper operation and to flush out potentially stagnant or rust-colored water.
- Safety showers must be tested annually for water flow. This is normally done by university personnel, but it is the responsibility of the laboratory owner to insure that this occurs.
- Water flow must be at least 30 gpm, per ANSI Z358.1-1998.
- Water must continue to flow once handle is released.
- Keep area around shower (including floor) clear of obstructions.
- Contact the building attendant at 7-2003 to arrange for testing or flushing.

Fire Extinguishers

All laboratories must have a fire extinguisher. This extinguisher must be located in an accessible, unobstructed location. All of the laboratory extinguishers are ABC rated, which means that they can be used on any fire.

Almost all fires are small in their early stage and can be put out quickly if the proper fire extinguisher is available, and the person discovering the fire has been trained to use the fire extinguisher at hand.

SAFETY EQUIPMENT (cont'd)

To be effective, portable fire extinguishers must be:

1. Approved by a recognized testing laboratory (Extinguishers manufactured in the U.S. are generally approved by Factory Mutual (FM) and listed by Underwriters' Laboratories, Inc. (UL));
2. Of the proper type for the class of fire expected;
3. Located where they are readily accessible for immediate use and in sufficient quantity and size to deal with the expected fire;
4. Inspected and maintained on a regular basis so that they are kept in good operating condition;
5. Operated by trained personnel who can use them effectively.

Fire extinguishers are classified by the type of fire that they will extinguish.

A **Class A** fire extinguisher is used for ordinary combustibles, such as wood, paper, some plastics and textiles. This class of fire requires the heat-absorbing effects of water or the coating effects of certain dry chemicals. Extinguishers that are suitable for **Class A** fires should be identified by a triangle containing the letter "A." If in color, the triangle should be green.

A **Class B** fire extinguisher is used for flammable liquid and gas fires such as oil, gasoline, etc. These fire extinguishers deprive the fire of oxygen and interrupt the fire chain by inhibiting the release of combustible vapors. Extinguishers that are suitable for **Class B** fires should be identified by a square containing the letter "B." If in color, the square should be red.

A **Class C** fire extinguisher is used on fires that involve live electrical equipment which require the use of electrically nonconductive extinguishing agents. (Once the electrical equipment is deenergized, extinguishers for Class A or B fires may be used.) Extinguishers that are suitable for **Class C** fires should be identified by a circle containing the letter "C." If in color, the circle should be blue.

A **Class D** fire extinguisher is used on combustible metals such as magnesium, titanium, sodium, etc., which require an extinguishing medium that does not react with the burning metal. Extinguishers that are suitable for **Class D** fires should be identified by a five- point painted star containing the letter "D." If in color, the star should be yellow.

Most of the fire extinguishers found in MTU labs are rated as ABC, which means that they can be used on all fires, except fires involving combustible metals.

SAFETY EQUIPMENT (cont'd)

Portable fire extinguishers must be visually inspected monthly by the laboratory owner. The inspection should assure that:

1. Fire extinguishers are in their assigned place.
2. Fire extinguishers are not blocked or hidden.
3. Fire extinguishers are mounted in accordance with NFPA Standard No. 10 (Portable Fire Extinguisher).
4. Pressure gauges show adequate pressure (CO₂ extinguisher must be weighed to determine if leakage has occurred).
5. Pin and seals are in place.
6. Fire extinguishers show no visual sign of damage or abuse.
7. Nozzles are free of blockage.

Operation:

-Remove extinguisher from wall and then **P-A-S-S**:

P: Pull pin.

A: Aim nozzle at base of flames.

S: Squeeze handle.

S: Sweep extinguisher back and forth and advance toward the flames.

Maintenance:

-All fire extinguishers must be checked monthly.

-Keep the area around the extinguisher free of obstructions.

Hydrostatic testing must be performed by trained personnel with proper test equipment and facilities. This must be done every 5 years if a carbon dioxide extinguisher, and every 12 years if a dry powder extinguisher. The University provides this service, but it is the responsibility of the laboratory owner to insure that this occurs. Please contact MTU OSHS if your extinguisher testing is not up-to-date.

Hoods

All operations involving toxic, flammable, reactive, corrosive, or noxious chemicals, or any operation involving fumes or dusts, should be performed in a laboratory hood, if possible. Laboratory hood air is exhausted directly outside the building and is not recirculated. Thus, hoods minimize chemical exposures and provide containment in the event of a fire or explosion.

Hoods should be installed in areas where it is necessary to vent toxic, flammable, and corrosive fumes directly to the outside atmosphere, and/or to provide containment for the use of these materials.

When heating flammable liquids and materials in a hood, use a heating mantle or oil bath - not an open flame or electrical hot plate. Vapors given off may contact the heat or ignition source, resulting in a fire.

SAFETY EQUIPMENT (cont'd)

Hoods should be located in areas with minimum air turbulence and in such a manner that, if involved with a fire, they will not block egress from the laboratory area. Hoods must not be located next to exit doors.

Operation:

- Check to insure that the hood is operating. The face velocity through the opening must be noticeable. For proper operation, air flow must be 80 to 125 feet per minute. All of the hoods in the Department of Chemical Engineering have air flow indicators.
- If the hood is not operating, either find the on/off switch or call the Central Heating plant (7-2707) to turn on the hood. You will need to tell physical plant the number of the hood (usually posted on the hood).
- Make sure the hood sash is in the correct position for proper air flow. Some hoods have arrows on them to indicate correct sash position. The hood sash provides a protective shield in the event of chemical splashing, glass container breakage, or small explosions.
- Hoods should be kept clean and uncluttered. Storage of chemicals and equipment inside the hood shall be kept to a minimum.
- Hoods shall not be used as a means of disposal for volatile chemicals by evaporation.
- The hood sash should be fully down, except when raised to work in the hood.

Maintenance:

- Hoods should be checked annually for proper air flow. The face velocity must be 80 to 125 feet per minute. This is normally done by the MTU Department of Occupational Safety and Health. Each hood should have a sticker indicating the last test date and the results.

Flammable Storage Cabinets

Flammable storage cabinets protect flammable chemicals from exposure to a fire and thus prevent these materials from contributing to the fire. The cabinets are of metal construction, with a number of shelves and a metal door and door lock.

Operation:

- Keep all flammable chemicals, including solvents, solids, small cylinders containing flammable gases, flammable wastes, etc. in the storage cabinet.
- Do not store anything on top of the cabinet - this will reduce the fire rating of the cabinet.
- All cabinets must be electrically grounded to prevent the accumulation of static charge on the cabinet. Contact the Manager of Laboratory Facilities if your cabinet is not grounded.
- Some cabinets are provided with removable vent openings. Do not open these since they will reduce the fire rating of the cabinet.
- If the chemicals have an offensive odor store them in a flammable cabinet with the

cabinet vent connected to the hood ventilation system..

18. CHEMICAL SAFETY

Introduction

The objective of this section is to provide guidance to all faculty, staff, students and participating guests who use hazardous materials so that they may perform their work safely. Many of these materials are specifically explosive, reactive, corrosive, flammable, or toxic; they may have properties that combine these hazards. Many chemicals are relatively non-hazardous by themselves but become dangerous when they interact with other substances, either in planned experiments or by accidental contact.

To avoid injury and/or property damage, persons who handle chemicals in any area of the department must understand the hazardous properties of the chemicals with which they will be working. Before using a specific chemical, safe handling methods must always be reviewed. Supervisors are responsible for ensuring that the equipment needed to work safely with chemicals is provided.

General Rules for Chemical Safety

- A. Material Safety Data Sheets (MSDS) must be available in the laboratory for all chemicals, including those in storage in the laboratory.
- B. When purchasing chemicals, purchase the smallest quantity necessary to complete the planned experiments. The cost of disposal of unused chemicals far exceeds the savings from quantity purchases.
- C. Skin contact with chemicals must be generally avoided.
- D. No more than 2-gallons of flammable solvent should be out in the laboratory at any one time. Store bulk flammable containers in a flammable storage cabinet. See the discussion on flammable storage cabinets in the Safety Equipment Section.
- E. Use a fire extinguisher for small chemical fires.
- F. All containers (including those in storage) must be labeled as to their contents and must have a "Right to Know Law" label attached. Any unlabeled container must be reported to the laboratory supervisor and be treated as a hazardous substance.
- G. Wear compatible gloves and apron when handling strong acids and bases.
- H. Use a grounding strap and/or dip leg when transferring flammable chemicals into a storage tank.
- I. Transport all chemicals using a safety carrier. A safety carrier is available in the stockroom for transporting chemicals. The chemical must be in a closed container.
- J. Chemical containers must be kept away from high temperatures, the edge of the lab bench, and other areas where an incident might lead to loss of containment.
- K. Mouth suction for pipetting or starting a siphon is not allowed.
- L. Unknown substances must be treated as toxic and flammable.
- M. Do not taste or smell any chemicals.
- N. Operations involving chemicals should generally be done in a laboratory hood. See the discussion on laboratory hoods in the Safety Equipment Section.

CHEMICAL SAFETY (cont'd)

- O. The laboratory must have two Right-To-Know signs on the door, as provided in the Appendix.

Chemical Storage

- A. MSDS's must be available for all chemicals stored.
- B. ALL chemicals stored must be properly labelled.
- C. No chemicals shall be stored on the top of lab benches or out in the open. Chemicals must not be stored over eye level height to prevent accidents from dropping containers.
- D. Flammable and volatile chemicals must be stored in a cabinet designated for flammable storage. See the discussion of flammable storage cabinets in the Safety Equipment section. Refrigerated storage of these chemicals requires a refrigerator rated for storing flammables.
- E. Acids and bases should be stored separately.
- F. Acid-resistant trays shall be placed under stored acid containers.
- G. Acid-sensitive materials such as cyanides and sulfides must be separated from acids.
- H. Oxidizable materials should be stored away from acids and bases.
- I. Stored chemicals must be examined on a regular basis by the laboratory personnel (at least annually) to inspect for deterioration, container integrity, and expired dates. Chemicals which are not being used should be disposed of or returned to Chem Stores for recycling.
- J. An inventory of stored chemicals must be maintained by the laboratory owner at all times. Unneeded items shall be properly discarded or returned to Chemical Stores. Store only what you are using.

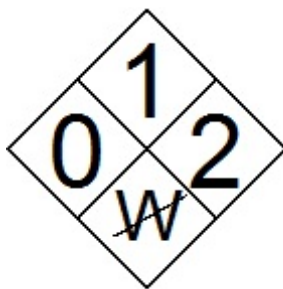
Chemical Labeling

All chemicals must be labeled, even during temporary transport. This includes lab samples, temporary containers, etc. A proper chemical label must include:

- ▶ Identity of contents
- ▶ Date material was acquired
- ▶ Disposal date (for unstable chemicals)
- ▶ Responsible person
- ▶ Hazardous characteristics
- ▶ Other pertinent safety information

The hazardous characteristics are frequently denoted using an National Fire Protection Association (NFPA) diamond. A sample diamond is shown below:

CHEMICAL SAFETY (cont'd)



The area with a "0" in the diamond denotes health hazard, the area with the "1" denotes fire hazard and the area with a "2" denotes reactivity hazards. The box at the bottom is used to denote special hazards, e.g. incompatible with water.

The hazards in the NFPA diamond are indicated by numbers 0 through 4. 0 means minimal hazard while 4 means extreme hazard.

	Health	Fire	Reactivity
Acetic acid, glacial	2	2	1
Acetone:	1	3	0
Acrolein:	3	3	2
Benzene:	2	3	0
Carbon monoxide:	2	4	0
Cyclohexane:	1	3	0
Ethane:	1	4	0
Ethylbenzene:	2	3	0
Ethyl alcohol:	0	3	0
Ethylene:	1	4	2
Ethyl ether:	2	4	1
Gasoline:	1	3	0
Glycerine:	1	1	0
Hexane:	1	3	0
Isopropyl alcohol:	1	3	0

Chemical Acquisition

- A. A commitment to acquire a chemical is a commitment to handle and use it safely, store it properly, and dispose of it properly when no longer required.
- B. All purchased chemicals must be acquired through Chemical Stores to insure that the MSDS is filed, that the chemical is inventoried, and that the proper hazard labels are attached.
- C. Chemical samples must be accompanied with an MSDS and shipped to MTU through Chemical Stores.
- D. The necessary spill response supplies must be present before a chemical is brought into

CHEMICAL SAFETY (cont'd)

the laboratory.

Chemical Disposal

All chemicals must be disposed of in a safe and environmentally friendly manner. Any chemical substance which is corrosive, flammable, reactive, toxic, radioactive, infectious, phytotoxic, mutagenic, or acutely hazardous must be treated as hazardous waste. Do not dispose of chemicals by evaporation in a fume hood or in the sink! Do not hesitate if any questions occur about the hazards of a material.

Collect and store chemical waste in containers which are clearly labeled. Do not combine containers unless the contents in each container is known, is compatible, and it is certain that it is safe to do so. Combined wastes are much more difficult and costly to dispose of properly.

Ordinary waste such as paper, cardboard, etc., may be placed in the wastebasket. However, contaminated waste must be disposed of separately in a labeled container.

See the Chemical Engineering Hazardous Waste Manual for details on proper and legal hazardous waste collection and disposal. This is available on the MTU Chemical Engineering web site.

Empty chemical containers must also be disposed of in an acceptable fashion. They must first be cleaned and then either returned to Chemical Stores or disposed through normal trash.



Request for Collection of Waste Chemicals

Requested by _____ Date _____

Department/Office/Division _____ Telephone number _____

Location of Waste Chemicals _____

Disposal Approved by _____ Date _____

Item No.	Chemical Name/Description	EPA Waste ID No.*	Physical State **	Quantity	Container Size
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

* Refer to EPA hazardous waste tables or contact OSHS

** Indicate whether waste is solid, liquid, gas, or sludge

CHEMICAL SAFETY (cont'd)

Regulated Chemicals

The following chemicals / materials are covered by special OSHA regulations and **require approval by the Chemical Hygiene officer prior to their use**. Many of these chemicals may require regular workplace monitoring and medical surveillance. The OSHA standards can be downloaded from the OSHA webpage at OSHA.gov, or obtained from the Chemical Hygiene Officer.

Chemical Name	OSHA Standard	CAS Number
Asbestos	1910.1001	
Coal tar pitch volatiles	1910.1002	
4-Nitrobiphenyl	1910.1003	92933
alpha-Naphthylamine	1910.1003, 1910.1004	134327
methyl chloromethyl ether	1910.1003, 1910.1006	107302
3,3'-Dichlorobenzidine	1910.1003, 1910.1007	91941
bis-Chloromethyl ether	1910.1003, 1910.1008	542881
beta-Naphthylamine	1910.1003, 1910.1009	91598
Benzidine	1910.1003, 1910.1010	92875
4-Aminodiphenyl	1910.1003, 1910.1011	92671
Ethyleneimine	1910.1003, 1910.1012	151564
beta-Propiolactone	1910.1003, 1910.1013	57578
2-Acetylaminofluorene	1910.1003, 1910.1014	53963
4-Dimethylaminoazo-benzene	1910.1003, 1910.1015	60117
N-Nitrosodimethylamine	1910.1003, 1910.1016	62759
Vinyl chloride	1910.1017	75014
Inorganic arsenic	1910.1018	
Lead	1910.1025	
Cadmium	1910.1027	
Benzene	1910.1028	71432
Coke oven emissions	1910.1029	
Bloodborne pathogens	1910.1030	
Cotton Dust	1910.1043	
1,2-dibromo-3-chloropropane	1910.1044	
Acrylonitrile	1910.1045	107131
Ethylene oxide	1910.1047	75218
Formaldehyde	1910.1048 50000	
4,4'-Methylenedianiline	1910.1050	101779
1,3-Butadiene	1910.1051	106990
Methylene Chloride	1910.1052	75092

CHEMICAL SAFETY (cont'd)

Chemical Spills

General Spill Information

The range and quantity of hazardous substances used in laboratories require preplanning to respond safely to chemical spills. Although the following tactics are prioritized in terms of usual preferred action sequences, each spill incident is unique and involves persons with varying levels of spill expertise and experience. Thus, for any individual incident, isolation of the spill and/or securing the area might best occur prior to or simultaneously with contacting 9-1-1.

The locations of emergency shower, eye wash, and other equipment must be known ahead of time.

Spills must be cleaned immediately. Every laboratory should have pre-existing plans and materials to clean up all spills that occur in that laboratory. Spills involving hazardous materials will require different tactics depending on the magnitude of the spill, the material's toxicity, reactivity, and flammability, routes of entry of the material into the body, and the promptness with which the spill can be safely managed.

Never assume gases or vapors do not exist or are harmless because of lack of smell.

Do not touch the spill without personnel protective equipment.

Where the spill does not present immediate personal danger, try to control the spread or volume of the spill. This could mean shutting a door, moving nearby equipment to prevent further contamination, repositioning an overturned container or one that has a hole in the bottom or side, or creating a dike by putting an absorbent around the spill.

If the vapors are non-toxic, increase the ventilation. Open closed fume hood sashes to the 12 inch or full open position. Laboratory doors may be opened to ventilate nontoxic vapors.

All information regarding the substances and quantities involved must be reported to the Chair of the Chemical Engineering Department (487-3132) and a representative of the MTU Department of Occupational Safety and Health (487-2118) so that the appropriate Federal, State and local agencies may be notified.

Minor Spills

Minor spills are small chemical leaks that usually are detected early and present no immediate danger to personnel or the environment. These spills can be safely corrected with the advice of knowledgeable laboratory or supervisory personnel. As a general rule, spills of 4 liters or less will be considered a minor spill, depending on the chemical(s) involved. Spills of highly toxic, reactive, or flammable materials less than 1 liter should generally be considered a minor spill.

CHEMICAL SAFETY (cont'd)

- A. Don't panic!
- B. If the spilled material is flammable, do not operate electrical switches unless to turn off motorized equipment. Try to remove heat sources, where safe to do so.
- C. Notify nearby persons and evacuate as necessary. Protect yourself, then remove injured person(s) to a safe place, if safe to do so.
- D. Close doors to the affected area.
- E. Remove contaminated clothing. Flush skin/eyes with water at least 15 minutes (up to 30 minutes is highly recommended); use soap for intermediate and final cleaning on skin areas. Forcibly hold eyelids open to ensure effective wash under eyelids. Make sure chemicals have not accumulated in shoes. Obtain medical attention for the victim.
- F. Identify or characterize the substance(s) involved. Refer to the MSDS for spill clean-up procedures.
- G. Once the spill is identified, if clean-up procedures can be handled safely by departmental personnel, proceed with spill clean-up procedures and clean-up kits designated on the MSDS or in departmental standard operating procedures.
 - Contain a spill by slowly sprinkling absorbent, starting at the edges, surrounding the spilled material, and move toward the center of the spill.
 - Collect residue, place in container, and contact the Chemical Hygiene Officer (CHO) or Manager of Laboratory Facilities for disposal information.
 - Clean the spill area with soap and water.
- H. If the clean-up cannot be handled safely by departmental personnel, contact the MTU Department of Occupational Safety and Health at 487-2118.

Major Spills

Major spills are accidental chemical discharges that present an immediate danger to personnel and/or the environment. Under these circumstances, leave the spill site immediately and send for help. Management of these spills is the responsibility of specially trained and equipped personnel. Call 9-1-1 for initial response. They will notify the appropriate persons/departments. An outside contractor has been selected to respond to large-quantity or dangerous spills. The MTU department of Occupational Safety and Health will assess the situation and decide if the situation warrants the response of the vendor or if the situation should be handled in-house. Spills of highly toxic, reactive, or flammable materials over 1 liter should be considered a major spill.

- A. Leave the spill site immediately and call 9-1-1. They will contact all appropriate persons/departments.
- B. If the spilled material is flammable, turn off ignition and heat sources, if safe to do so.
- C. Remove injured persons, if safe to do so. Remove contaminated clothing. Flush skin/eyes with water at least 15 minutes (up to 30 minutes is highly recommended); use soap for

CHEMICAL SAFETY (cont'd)

intermediate and final cleaning on skin areas. Forcibly hold eyelids open to ensure effective wash under eyelids. Make sure chemicals have not accumulated in shoes. Obtain medical attention for the victim.

- D. Close doors to the affected area.
- F. Isolate the area. Do not allow re-entry.
- G. Campus Police will be trained in emergency response tactics as the first responders.

Incompatible Chemicals

Certain hazardous chemicals should not be mixed or stored with other chemicals because a severe reaction can take place or an extremely toxic reaction product can result. The label and MSDS will contain information on incompatibilities. The following table contains examples of incompatible chemicals (reference source: chem-safety.com):

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

CHEMICAL SAFETY (cont'd)

CHEMICAL	KEEP OUT OF CONTACT WITH
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

CHEMICAL SAFETY (cont'd)

CHEMICAL	KEEP OUT OF CONTACT WITH
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

19. EQUIPMENT SAFETY

Laboratory equipment may be operated safely only if the associated hazards are identified, understood, and controlled. This section lists known hazards and good safety practices for common laboratory equipment.

Electrical

- A. Use the "left-hand rule" in operating electrical disconnects, i.e. use the left hand to move the handle up or down. This positions your body off to the side of the power box, preventing an exposure in the event of explosion of the box or fire.
- B. Power must be off before making electrical connections.
- C. Avoid splashing or spraying water on electrical connections, wall sockets, and junction or power boxes.
- D. Keep extension cords away from traffic and water.
- E. Use 3-pronged plugs with a ground connection.
- F. Use a Class C Fire Extinguisher if energized electrical systems are involved.
- G. Do not use frayed power or extension cords or those with broken plugs (either end).
- H. Use a ground-fault interrupter (GFI) whenever water may be present.

Drying Ovens

Several types of drying ovens are available and the correct unit depends on the type of material dried.

Natural convection or **direct drying ovens** contain the heating element within the drying chamber. For these ovens it is difficult to control the temperature within the oven space with a wide variation in temperature expected. The heat source, such as electric coils, may be at a very high temperature. Thus, a high probability exists for a fire when flammable or combustible materials are dried in these ovens. A danger of fire or explosion also exists if the material off-gases a flammable vapor. A Job Safety Analysis (JSA) must be completed prior to the drying of these materials in these ovens. The JSA must be reviewed and approval by the Chemical Hygiene Officer (CHO) or Manager of Laboratory Facilities, prior to usage.

Indirect drying ovens use air to move the heat into the oven from an external heating source. An active control system controls the temperature within the oven. These ovens can be used to dry materials that are flammable as long as the oven temperature is kept well below the ignition temperature of the material, off-gas, or product.

If the material dried is toxic, or produces a toxic off-gas or product, then the oven must be either contained within a hood or properly vented. Proper personal protective equipment must be used.

Mercury or alcohol thermometers should not be used to measure the temperature of the oven due to the potential for breakage of the thermometer, and spilling of the mercury or alcohol inside the

EQUIPMENT SAFETY (cont'd)

oven. These should be replaced with dial or electronic thermocouples - but care must be taken to insure that the metal dial or electronic thermocouples do not touch the heating coils resulting potential electrical shock to the user. Thermometers can be used if they are provided with a thermowell to protect the thermometer inside the oven.

All ovens require a log book, to record the date of usage, the person responsible, the maximum temperature, and the material dried.

Gas Cylinders

- A. Cylinder contents are under pressure; keep cylinders upright and secured to a sturdy support with a chain.
- B. The gas or liquid contained in the cylinder should be clearly identified on the container.
- C. If a cylinder has been emptied, clearly label this information on the container.
- D. Keep the valve cover screwed securely on top of the cylinder while storing or transporting.
- E. Store cylinders away from high temperatures.
- F. Do not store cylinders with flammable contents near oxygen cylinders.
- G. Always move a cylinder tank with a cart; cylinder must be chained to the cart.
- H. All cylinders must have a point of use shut-off, separate from the main cylinder valve. This valve should be a 1/4-turn valve to insure that the flow can be shut-off quickly.
- I. Once the cylinder is installed:
 - 1. Make sure connecting pipes and hoses are tight and in good condition to prevent leakage.
 - 2. Check for leaks with soapy water; bubbles will form if any leaks are present.
- J. Fully open main cylinder valve only after the proper cylinder regulator has been attached.
- K. The cylinder regulator must be supplied with the proper fitting to connect to the tank.
- L. Do not use oiled gauges/regulators for air, oxygen, or other oxidants.
- M. Check hydrostatic test date when receiving cylinder. Test date must be less than 5 years ago.

Glassware

- A. Glassware and thermometers must be transported in a safety carrier (bucket, chemical bag, or other suitable container).
- B. Use hand protection when inserting glass tubing into rubber stoppers, corks, or rubber tubing.
- C. Glass tubing should be fire polished and lubricated before insertion into rubber stoppers or rubber tubing.
- D. Always wear eye protection when using glassware.

EQUIPMENT SAFETY (cont'd)

- E. Take care in storing and handling glassware.
- F. Discard or replace damaged glassware.
- G. Dispose of broken glass in a designated broken glass container. These containers can be obtained from Chem Stores. When filled, please notify the custodians and they will dispose of the containers.
- H. Use only vacuum-designed glassware for vacuum purposes. Protect all evacuated or pressurized glassware by wrapping with tape or plastic mesh.

Manometers

The use of mercury manometers and barometers should be discouraged - they frequently result in mercury spills. Suitable mechanical gauges are readily available at relatively low cost. To insure safe operation of the manometer, follow these guidelines:

- A. A mercury spill kit is required in the laboratory.
- B. By-pass valve must be open before opening valves in lines to manometer legs.
- C. Open valve to low pressure source first and then valve to high pressure source.
- D. Close by-pass valve slowly and observe manometer reading. If manometer level is going off-scale, quickly open by-pass valve. This means that the pressure is beyond the range of the manometer and may result in spilling the manometer liquid.
- D. Open by-pass valve immediately after taking the measurement.
- F. Close valve to high pressure source first and then valve to low pressure source.
- G. In the event of a mercury spill, contact the laboratory supervisor or the MTU Occupational Safety and Health Office (487-2118). See the section on mercury spills under the section on CHEMICALS in the Appendix.
- H. Provide secondary spill containers for all devices containing mercury.

Mixing and Stirring Devices

- A. Keep hands, hair, and loose clothing away from the agitator.
- B. Make sure agitator is off before adding material to the tank.
- C. If solids have settled to the bottom of the tank, they should be stirred manually before starting the agitator.
- D. Make sure the agitator is immersed in the solution to be mixed before starting motor.
- E. Turn off motor and wait until the shaft stops turning before removing the agitator from the mixed solution.

Portable Ladders

- A. Do not use the top two steps and do not lean while using a ladder. Someone should hold the base of the ladder while it is being used.
- B. Avoid hitting lights or electrical wires while moving a ladder - this could pose an

EQUIPMENT SAFETY (cont'd)

electrocution hazard, particularly if the ladder is conductive. Ladders used in areas where there is the potential for electrical contact must be non-conductive.

- C. Ladders over 6 feet long must be transported by two people and a second person must stabilize the ladder while the other is using it, if necessary.
- D. Make sure the ladder is about 1 foot away from the vertical support for every 4 feet of ladder height between the foot and the top support.

Pumps, Fans, Blowers, and Compressors

- A. Make sure that guards on moving parts and electrical connections are in place.
- B. Keep clothing, hands, jewelry, and hair away from moving parts.

Refrigerators in the Laboratory

Refrigerators (and freezers) are important items of lab equipment and are common in research laboratories. Like many pieces of lab equipment, however, there are hazards connected with them of which lab personnel must be aware. *Food or drink for human consumption must never be stored in a refrigerator containing laboratory chemicals.*

1. Flammable Materials Stored in Lab Refrigerators/Freezers

A household or commercial refrigerator cannot be used for flammable materials storage because it has many sources of ignition: the thermostat, the interior light, the light switch on the door, and the defrost heater, among others. Most of these are found in the space being cooled. Also, self-defrosting units contain an internal drain that can permit internal vapors to flow into the compressor space below. A flammable-material storage refrigerator has all these sparking devices moved to the exterior of the unit. While it may be possible to safely modify a normal refrigerator, department policy prohibits the use of non-rated refrigerators for storing flammable chemicals.

Inside the confined space of a refrigerator, vapors from carelessly or hastily closed or broken containers and beakers can escape and accumulate. If the concentration exceeds the lower flammable limit of the material, a spark may cause ignition. If these vapors ignite and explode, anyone in the vicinity could be seriously hurt or killed.

The cost of flammable storage refrigerator is sometimes two to four times more than conventional refrigerators used in the home. If money is tight and flammable materials are not currently used, it is tempting to save the difference and opt for the lower priced refrigerator. However, remember that the average lifespan of a refrigerator is about 20 years; there often is no guarantee that common flammable lab solvents will never be used at some time in the life of the unit. Although the current researchers may not be using them, the next researchers might. It may seem like a high initial cost, but over the life of the unit, it is really a very small price to pay for

EQUIPMENT SAFETY (cont'd)

elimination of a source of fire and explosion in the lab.

If the refrigerator or freezer in your lab is not appropriate for flammables storage, this must be clearly marked. Bear in mind that despite signs posted on the refrigerator, it is virtually certain that eventually someone will use the refrigerators incorrectly.

2. Other Chemicals Stored in Lab Refrigerators/Freezer

Vapors from improperly sealed or broken containers can accumulate in the refrigerator. In some cases, the vapors may be toxic, causing excessive exposure to anyone opening the refrigerator door. Unless the material has a distinct or offensive odor, the individual may not be aware of this exposure. All lab personnel must be conscientious in properly sealing any containers stored in refrigerators and freezers. Covering beakers and flasks with aluminum foil or plastic wrap may not be sufficient. Corks and glass stoppers are good as long as they form a tight seal. Screw-cap tops with a seal inside are much better, when screwed on firmly. No type of top is foolproof when used in haste.

Lab personnel should also ensure that all chemicals are properly labeled. Chemicals which are no longer in use must be disposed of in a proper manner.

Reactive chemicals are frequently stored in a refrigerator to prevent the material from reacting or decomposing. Many of these chemicals will react explosively if stored at room temperature. Refrigerators containing these types of chemicals should have a high temperature alarm to alert the laboratory occupants of refrigerator failure.

3. Periodic thawing of the freezer compartment is necessary to prevent the severe build-up of frost.

Steam Lines and Condensate Lines

Steam and condensate lines in the laboratory represent a thermal hazard. All lines with an external surface temperature exceeding 150°F must be insulated. In addition, steam lines also represent a hazard due to water hammer. This occurs when hot steam is mixed with cold water, resulting in severe "knocking" of the pipes.

Autoclaves represent a particular type of hazard since they use high pressure steam. They are not covered in this manual. Please contact the Manager of Laboratory Facilities or the Chemical Hygiene Officer.

General guidelines for steam line usage in the laboratory include:

- A. All lines, vessels and jackets containing steam must be rated for the steam pressure and temperature under both normal and abnormal conditions.
- B. Use insulated gloves for operating steam valves that have short valve stems.
- C. Open valves slowly and only to the desired extent.
- D. Keep hands and clothing away from steam lines - lines must also be insulated.
- E. Discharge lines from steam should extend into a drain.

EQUIPMENT SAFETY (cont'd)

- F. Stay clear of condensate/steam discharge lines, especially during initial start up.
- G. Glassware is sensitive to thermal and pressure shock - start steam service slowly to glass equipment.

Vacuum Apparatus

- A. Locate relief valves or vent lines and understand their use.
- B. Inspect these protective devices periodically.
- C. Use only vacuum rated glassware in vacuum lines. Tape glassware to provide protection from imploding fragments.
- D. Release vacuum when not in use.

20. LASER SAFETY

Introduction

This section provides guidance for the safe use of lasers and laser systems. It is derived from ANSI Z136.1, Standard for the Safe Use of Lasers, prescribed by the Department of Energy and OSHA regulations.

The ANSI Standard establishes a hazard classification scheme based on the ability of the laser beam to cause biological damage to the eye or skin. This scheme is used to place each laser into one of four classes; each laser must meet the laser safety requirements specified for its class.

Laser Classes

Injury potential from exposure to a laser beam is the basis of the following hazard classification scheme:

A Class 1 laser is one that is considered to be incapable of producing damaging radiation levels and is, therefore, exempt from any control measures. As a matter of good practice, any needless direct exposure of the eye to a Class 1 laser should be avoided.

A Class 2 laser emits accessible, visible radiation at levels where damage from chronic exposure is possible. Class 2 lasers must have a caution label affixed to the external surface of the device.

A Class 3 laser requires control measures to prevent viewing of the direct beam since biological damage to human tissue is possible from acute exposure. Class 3 lasers are subdivided into two classes, Class 3a and Class 3b.

A Class 4 laser requires the use of controls that prevent exposure of the eye and skin to the direct and diffusely reflected beams. Whenever possible, the entire beam should be controlled.

Lasers or laser systems certified for a specific class by a manufacturer in accordance with the Federal Laser Product Performance Standard may be considered as fulfilling all classification requirements of this regulation. In cases where the laser or laser system classification is not provided, or where the class level may change because of a change from the use intended by the manufacturer, or because of the addition or deletion of engineering control measures, the laser or laser system must be classified by the MTU Department of Occupational Safety and Health.

LASER SAFETY (cont'd)

Employee Responsibilities

Employees who work near a laser:

Must not energize or work with or near a laser unless authorized by the laboratory supervisor.

Must receive appropriate training and comply with the safety regulations.

Must notify the supervisor immediately of any known or suspected accident involving a laser. (If the supervisor is not available, the employee must immediately notify MTU Public Safety by dialing 1-2-3 using a campus phone.)

User Responsibilities

It is the responsibility of the user to notify the Chair of the Department whenever the decision is made to fabricate, purchase or otherwise acquire a laser. This will facilitate the proper functioning of the department's laser safety program and afford the user the opportunity to be informed about the safety considerations appropriate to the laser he/she is acquiring, prior to its actual use. To help ensure that oversights do not occur, the MTU Purchasing Department has been asked to refer each requisition for a laser to the department for approval before an order is placed.

Operational Safety Procedures for Class 3 & 4 Lasers

Each Class 3 or Class 4 laser or laser system must have an Operational Safety Procedure (OSP) located near the unit. It must contain at least the following information:

- ▶ Name of the laser system supervisor
- ▶ List of authorized users
- ▶ General description of the laser or laser system
- ▶ Specific safety control measures used
- ▶ Specific alignment procedures used, if applicable
- ▶ Eye protection required, if applicable
- ▶ Emergency instructions

LASER SAFETY (cont'd)

Control Measures

Control measures are applied after the laser has been properly classified.

Control measures are divided into four categories:

1. Physical (enclosures, interlocks, beam stops, etc.)
2. Protective equipment (goggles, clothing, etc.)
3. Warning devices (signs, lights, labels, etc.)
4. Procedures

Physical measures are almost always the preferred method for controlling access to laser radiation.

Class 1: There are no control measures or warning labels required, but needless exposures of the eye should be avoided as a matter of good practice.

Class 2: An appropriate warning label must be affixed to the laser housing or control panel and have a protective housing.

Class 3: Class 3 lasers are divided into two groups, Class 3a and Class 3b. Class 3a lasers are those which have an accessible output power between 1 and 5 times the lowest appropriate Class 3 exposure level and which do not exceed the appropriate maximum permissible exposure limit. For Class 3 visible lasers, the output range is 1 - 5 mW laser beam with optical instruments.

Class 3b lasers require the following additional control measures:

Training: All persons must be duly informed about the hazards of their particular laser operation.

Engineering Controls: Priority must be given to the appropriate safety mechanisms (i.e., shutters, interlocks, stops, beam enlarging systems, etc.) as an integral part of the system.

Control Area: Only authorized personnel are allowed to operate laser systems. Spectators are not permitted into the area unless appropriate supervisory approval has been obtained and protective measures taken. If the laser beam is not enclosed, special emphasis must be placed on control of the path of the laser beam. The area must be posted with the appropriate warning sign(s).

Alignment Procedures: Must be performed in such a manner that primary beam or a specularly reflected beam does not expose the level in excess of the maximum permissible exposure limit.

LASER SAFETY (cont'd)

Equipment Labeling: Warning labels with the appropriate statement must be affixed to a conspicuous place on the laser.

Eye Protection: Eye protective equipment specifically designed to protect against radiation from the particular kind of laser must be used when engineering and procedural controls are inadequate.

Skin protection: Skin protection is required to prevent laser damage to the skin.

Class 4: High-power lasers require more rigid control measures because there is a greater risk of injury from hazardous diffuse reflections. The entire beam path capable of producing reflections must be controlled. Controls must rely primarily on positive engineering safeguards and secondarily on procedural controls. In addition to the control measures outlined under Class 3 lasers, the following Class 4 control measures must be applied:

Key-switch: All lasers must be provided with an operative, keyed, master interlock or switching device. The key must be removable, and the laser must not be operable when the key is removed.

Control Area: Operations must be optically isolated in an area designated for laser(s), and access to the area must require appropriate authorization. The area must be posted with the appropriate warning sign(s).

Interlocks: Safety latches or interlocks will usually be required to deactivate the laser in the event of an unexpected entry into laser- controlled areas. The design of interlocks must be such as to allow both rapid egress by the laser personnel and admittance under emergency conditions. For such emergency conditions a control-disconnect switch (panic button) must be available for deactivating the laser. Interlocks must not allow automatic re-energizing of the power supply but be designed so that the power supply or shutter must be reset manually. The person in charge of the laser-controlled area is permitted to momentarily override the room access interlocks when continuous operation is necessary, but specification for the override must have the approval of the Chair of the Department.

LASER SAFETY (cont'd)

Laser Housing

The protective housing on any Class 2, Class 3, or Class 4 laser system must limit the maximum accessible laser radiation to that level which defines the classification desired. The control measures appropriate to the classification apply when the laser is in normal operation.

Each enclosed laser system must be provided with a minimum of two operative safety interlocks for any portion of the protective housing, which, by design, can be removed or displaced during normal operation. In this manner, failure of any single mechanical or electrical component in the redundant interlock system will not prevent the total interlock system from functioning.

Viewing windows incorporated into an enclosed laser must be of a suitable filter material which attenuates the laser radiation to levels below the maximum permissible exposure limit.

Additional Controls

Since infrared and ultraviolet radiations are invisible, particular care must be taken when using these laser systems. Thus, in addition to the control measures that apply to the laser hazard classification, the following controls also apply:

Infrared lasers ($>0.7 \mu\text{m}$): The beam from a Class 3 laser should be terminated by a highly absorbent, non-specular backstop. Class 4 laser beams should be terminated by a fire-resistant material. (Note: Many surfaces which appear dull visually can act as reflectors of infrared radiation.)

Ultraviolet lasers ($<0.4 \mu\text{m}$): Exposure to ultraviolet radiation must be minimized by using shield material which attenuates the radiation to levels below the maximum permissible limit for the specific UV wavelength. Special attention must be given to the possibility of producing hazardous byproducts, such as ozone, and the formation of skin-sensitizing agents.

For both infrared and ultraviolet lasers, a warning sign and light should be displayed in a conspicuous location, warning those in the area when the laser is being operated.

Protective Eyewear

Laser protective eye wear must be worn whenever operational conditions may result in a potential eye hazard.

All protective eye wear must be clearly labeled with the optical density at the appropriate laser wavelength(s). Adequate optical density must be weighted with the need for adequate visible light transmission. Periodic inspection must be made to ensure that pitting, cracking, etc., will not endanger the wearer. The frame of the protective eye wear should also be inspected for

LASER SAFETY (cont'd)

mechanical integrity and light leaks.

Signs

All signs must be conspicuously displayed at entrances to controlled laser areas.

A standard laser sign is available to denote all laser systems. This sign includes a "Danger" warning and a beam with a "starburst." In the space below the tail on the sunburst, place the type of laser or laser system and its classification. In the space above the tail on the sunburst, place any pertinent precautionary instructions or protective actions which are required, such as:

For Class 3a: "Laser Radiation - Do Not Stare into Beam or View Directly with Optical Instruments."

For Class 3b: "Laser Radiation - Avoid Direct Exposure to Beam."

For Class 4: "Laser Radiation - Avoid Eye or Skin Exposure to Direct or Scattered Radiation."

Additional precautionary instructions or protective actions that may also be provided are: Invisible, Knock Before Entering, Do Not Enter When Light Is On, Restricted Area, etc.

Related Hazards

The operation of lasers and laser systems, like any industrial or technological process, involves possible related hazards. Potential hazards related to laser use include: electrical, explosion, fire, compressed gases, cryogenic liquids, toxic materials, noise, ultraviolet light, and ionizing radiation.

21. POSSIBLE ACCIDENTS

When injuries occur it is important to respond properly to aid those injured and to prevent further injury. For serious injuries, call 9-1-1 as soon as possible.

MTU faculty, staff and students are not expected to be familiar with treatment of injuries resulting from a laboratory accident. This section is provided for information purposes primarily for identification of the various injuries so that appropriate medical assistance may be obtained.

For bodily injuries the possibility exists that the person performing the emergency response will be exposed to blood, body fluids, and/or possible infectious agents. Please contact MTU Occupational Safety and Health at 7-2118 for information on the MTU blood-borne pathogens policy.

Asphyxiation

OSHA requires an oxygen concentration of at least 19.5% in all work spaces. Any atmosphere with less than 19.5% oxygen should not be entered without an approved self-contained breathing apparatus (SCBA). If the percentage of oxygen drops to:

1. 16%, a person experiences impaired judgment and breathing
2. 14%, a person experiences faulty judgment and rapid fatigue
3. About 10%, a person can lose consciousness without warning
4. Between 6 and 8%, a person would probably die
5. Between 4 and 6%, a person would be in a coma and die "in less than 40 seconds."
6. One breath of pure nitrogen results in almost instant loss of consciousness.

Burns - 1st Degree

Source:

- Light contact with hot objects.
- Scalding by direct contact with hot water or steam.
- Slight contact with concentrated acids or bases or prolonged contact with dilute acids or bases.

Characteristics:

- Reddening of the skin.
- Mild swelling.
- Very painful.

Emergency Response:

- Keep burn area clean.
- Medical treatment may be necessary.

POSSIBLE ACCIDENTS (cont'd)

Burns - 2nd Degree

Source:

- Contact with hot water or steam.
- Flash burns from flammable liquids such as kerosene.
- Major contact with concentrated acids or bases.

Characteristics:

- Reddening and blistering of the skin.
- Considerable swelling.
- Wet appearance on the surface of the skin due to the loss of plasma through damaged layers of the skin.
- Very painful.

Emergency Response:

- Gently clean the skin. Pat gently, do not rub.
- Get medical attention immediately.

Burns - 3rd Degree

Source:

- Flames.
- Ignited clothing.
- Immersion in hot liquids.
- Electricity.
- Contact with hot objects.

Characteristics:

- Burns involve the entire thickness of the skin, with or without charring.
- Temperature and duration of contact are important factors in determining extent of tissue destruction.

Emergency Response:

- DO NOT remove adhered particles of charred clothing.
- Do NOT apply ointment, commercial preparations, grease, or any home remedy.
- Cover burns with a thick, sterile dressing.
- If the hands are involved, keep them above the level of the victim's heart.
- Keep burned feet or legs elevated.
- Have victims with face burns sit up and keep them under continuous observation for breathing difficulty. If victim has a hard time breathing, an open airway must be maintained.
- Do not immerse an extensively burned area or apply ice water over it because cold may intensify the shock reaction. However, a cold pack may be applied to the face or the hands or feet.
- Treat for shock.

POSSIBLE ACCIDENTS (cont'd)

- Arrange for immediate medical attention.
- Transport to the hospital.

Chemical Burns - Skin

Source:

- Strong acids and bases.
- Corrosive chemicals.
- Neutralizing agent:
 - The agent itself may be too strong.
 - The heat of reaction may result in burns to the skin.
 - The reaction products formed may burn the skin.

Emergency Response:

- Use the safety shower.
- Remove IMMEDIATELY all contaminated clothing, while under the safety shower.
- Thoroughly drench with water.
- Flood acid burn with a dilute solution of bicarbonate soda.
- Flood alkali burn with a dilute solution of vinegar.
- Get medical treatment immediately.

Chemical Burns - Eyes

Emergency Response:

- Thoroughly drench with water (must hold eyes open) for 15-20 minutes.
- Use eye wash fountain.
- Get medical treatment immediately.

Chemical Ingestion

Emergency Response:

- Contact Poison Control Center (800-562-9781).
- If specified by the Poison Control Center, or on the MSDS sheet, administer: Syrup of Ipecac, granulated charcoal, or Epsom salts, as directed.
- Get medical attention immediately.

POSSIBLE ACCIDENTS (cont'd)

Chemical Inhalation

Symptoms:

- Excessive flow of tears.
- Choking and coughing.
- Chest pain.
- Nausea and vomiting.

Emergency Response:

- Move from area immediately to fresh air.
- Absolute rest, do not allow victim to move about.
- Apply artificial respiration if necessary.
- Get medical attention immediately.

Electrical Shock

To prevent electrical shock from occurring, make sure all cords are grounded and keep all electrical areas (including floor space) dry during performance of the experimental operation.

Emergency response:

- Assume that the power is still on.
- Locate the main power switch and turn off. **IMPORTANT:** Do this before touching the victim.
- If a live wire is trapping the victim, remove it with a long, dry object such as a broom handle, rope, or dry cloth. Be sure your hands are dry and that you are standing on a dry surface.
- Once electrical contact has been broken, check to see if the victim is conscious and breathing.

First Aid:

- If breathing has stopped, begin artificial respiration and get medical attention immediately.
- If cardiac arrest has occurred, begin CPR if qualified. Get immediate medical attention.
- Treat any burns if they occur.

Miscellaneous:

- Have an electrician inspect the accident area before turning the electricity back on.
- Get permission from the MTU Department of Occupational Safety and Health (487-2118) before turning the electricity back on.

22. RADIATION HAZARDS

Radiation sources represent a significant hazard in the laboratory. The proper handling and regulatory reporting requirements for these materials are substantial and beyond the scope of this document. Please contact the MTU Department of Occupational Safety and Health for details prior to acquisition of any radioactive materials or generators.

23. BIOSAFETY

Biosafety is a complex subject and is beyond the scope of this document. Contact the department CHO or MTU OSHS for assistance with these issues. The U. S. Centers for Disease Control has an excellent web site containing detailed information on biosafety. This web site is located at:

www.cdc.gov/od/ohs/biosfty/biosfty.htm

APPENDICES

APPENDIX A. ACCIDENT REPORTING FORM



Occupational Safety and Health Services (2007)

OSHS Case Number: _____

Supervisor's Incident Report

☞ ☞ PLEASE READ THE INSTRUCTIONS BEFORE COMPLETING THIS FORM! ☞ ☞

This form should be completed by the IMMEDIATE SUPERVISOR and NOT THE INDIVIDUAL involved in the incident.

It is the Supervisor's responsibility to initiate necessary corrective actions and to report the action taken (or to be taken in the case of training or a repair, etc.) on this form. It is essential that the cause(s) of the incident be identified and corrected where possible to avoid a reoccurrence.

This form must be completed **within 24 hours after learning of the incident** and returned to the OSHS office.

Provide as much detail as possible and do not leave blank spaces, indicate none, N/A, or unknown where appropriate. Attach additional information if needed.

Person Involved: _____ Male: _____ Female: _____
(Last Name) (First Name) (Middle Initial)

Local Home Address: _____ City: _____ Zip: _____

Birth Date: ____/____/____ Phone: _____ Dept _____ Job Title: _____

Status (Check One): ☐ Employee ☐ Student Employee ☐ Student ☐ Other: _____

Employee Identification Number: _____

Date of Hire at MTU: ____/____/____ Years of (MTU) Experience in Present Position: _____

Indicate Medical Treatment Required (answer each question):

- | | YES | NO | |
|-------------------------------|--------------------------|--------------------------|----------------|
| a. First Aid Given? | <input type="checkbox"/> | <input type="checkbox"/> | By Whom: _____ |
| b. Treated by Doctor? | <input type="checkbox"/> | <input type="checkbox"/> | Who: _____ |
| c. Treated in Emergency Room? | <input type="checkbox"/> | <input type="checkbox"/> | Where: _____ |
| d. Hospitalized Overnight? | <input type="checkbox"/> | <input type="checkbox"/> | Where: _____ |

Date Employee will Return to Work: ____/____/____ OR Anticipated Date: ____/____/____

Date of Incident: ____/____/____

Time of Incident: _____ am/pm

Time employee began work: _____ am/pm

What was the employee doing just before the incident occurred? Describe the activity, as well as the tools, equipment or material the employee was using. Be specific. *Examples:* "climbing a ladder while carrying roofing materials"; "spraying chlorine from hand sprayer"; "daily computer key-entry."

What happened? Tell us how the injury occurred. *Examples:* "When ladder slipped on wet floor, worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; "Worker developed soreness in wrist over time."

Where did the incident occur? Building: _____ Room Number: _____ Other: _____

What was the injury or illness? Tell us the part of the body that was affected and how it was affected; be more specific than "hurt," "pain," or "sore." *Examples:* "strained back"; "chemical burn, hand"; "scalp laceration."

Injury description (fill-in blank or circle choice):

Body Part(s) Involved: _____ **AND**

(Circle as appropriate) left right upper lower top bottom

Type of injury/illness (e.g. cut, strain, crush, etc.): _____

What object or substance directly harmed the employee? *Examples:* "concrete floor"; "chlorine"; "radial arm saw." If this question does not apply to the incident, write "NA".

If the incident involved a fatality, Date of Death: ____ / ____ / ____ **AND contact OSHS immediately.**

Describe any corrective actions taken or to be taken as a result of this incident: _____

If a corrective action **will be** taken later, it will be followed up by whom: _____

Supervisor's Signature: _____

Date: ____ / ____ / ____

Supervisor's Name (please print): _____

Work Phone: _____

Department: _____

**Send original to OSHS
Keep a copy for your file**

APPENDIX B. CHEMICALS

The following pages present information relevant to chemicals typically used in chemical engineering laboratories. This section will be expanded to include additional chemicals in the future. More detailed information on specific chemical handling and usage can be found in *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, National Academy Press, 1995.

Liquid Nitrogen

Liquid nitrogen is frequently used in chemical research laboratories for the purpose of cooling. Liquid nitrogen is a valuable coolant because of its low boiling point (bp $-196\text{ }^{\circ}\text{C}$), inexpensive price, and low toxicity. In comparison to liquid air, which was previously used as a popular coolant, liquid nitrogen has the advantage that it does not support combustion.

Handling Liquid Nitrogen: Personal Protection

Cryogenic liquids such as liquid nitrogen can cause very severe burns upon eye or skin contact. Splashes are common when handling liquid nitrogen, and safety goggles must therefore be worn at all times when working with this material. In addition, protective gloves that can easily be removed in the event of a spill should be worn when handling liquid nitrogen (alternatively, potholders may sometimes be more convenient for handling small containers of cryogenic materials). Particular care must be taken to prevent uninsulated vessels containing liquid nitrogen from coming into contact with unprotected parts of the body, since extremely cold materials can become firmly bonded to the skin such that separation is not possible without serious injury.

Contact of the skin with liquid nitrogen can cause severe cryogenic burns; the tissue damage that results is similar to that caused by frostbite or thermal burns. Since small amounts of liquid nitrogen quickly evaporate from the surface of exposed skin, some inexperienced workers may mistakenly underestimate the risk of cryogenic burns when working with this material. In fact, it is not unusual for spills and splashes of liquid nitrogen to become trapped under rings, bracelets, watchbands, or inside gloves, and this can result in serious and painful burns.

Containers for Liquid Nitrogen

The properties of some materials (including metals) change drastically when exposed to cryogenic liquids such as liquid nitrogen. Containers for such liquids must therefore be selected carefully to ensure that they can withstand the temperatures and pressures they may be exposed to. Liquid nitrogen is commonly stored in Dewar flasks which should be taped to minimize the hazard in the event of an implosion.

Cold Traps Cooled with Liquid Nitrogen

A common use of liquid nitrogen is as a coolant for traps incorporated in vacuum lines. Extreme care must be employed when using liquid nitrogen as a cold trap coolant. Systems including liquid nitrogen traps must never be opened to the atmosphere until the trap is removed from the coolant. Oxygen has a higher boiling point ($-183\text{ }^{\circ}\text{C}$) than nitrogen ($-196\text{ }^{\circ}\text{C}$), and will condense out of the atmosphere and collect in a liquid-nitrogen cooled vessel open to the air. **Liquid oxygen forms highly explosive mixtures with many organic materials.** If you suspect liquid oxygen has condensed in a cold trap, then shield the trap (with an explosion shield, closed hood window, etc.), post a sign indicating the danger, and allow the trap (vented to the atmosphere) to slowly warm to room temperature.

CHEMICALS (cont'd)

Liquid Nitrogen and Condensed Argon

Argon, a gas commonly employed as an "inert atmosphere" for chemical reactions, distillations, and other laboratory operations, also has a boiling point (-186 °C) which is higher than that of nitrogen. Consequently, liquid argon will condense in a reaction vessel under an argon atmosphere which is cooled with liquid nitrogen. This creates an extremely hazardous situation, since if the vessel is then removed from the coolant, the liquid argon will instantly vaporize, expanding in volume by a factor of 847! Even if the vessel is vented (e.g. to an inert gas line), an explosion is very likely due to the rapid increase in pressure in the vessel. Consequently, never cool an apparatus that is under an argon atmosphere using liquid nitrogen.

Transportation

Inside buildings, from room to room, the best transport is by Dewars which either have carrying handles (4 L and less) or are on wheels (larger Dewars), and which have pressure relief valves or pressure venting lids. (A wide-base Dewar which is stable on a wheeled cart qualifies as "on wheels.")

For short distances in hallways it is acceptable to hand-carry a pint (~ 500 mL) or smaller Dewar of nitrogen which has no handles, if and only if

- the Dewar is your only load (no books, no coffee, no other items), and
- the vessel has a venting lid (a cork or loose stopper is fine), and
- you are carefully watching for people who will run into you, and
- the vessel is carried with both hands and as far away from your face as comfortably possible.

Dispensing Liquid Nitrogen

Liquid nitrogen must be dispensed only into smaller Dewars which either have carrying handles or are on wheels, and which have pressure relief valves or pressure venting lids. (A wide-base Dewar which is stable on a wheeled cart qualifies as "on wheels".)

Persons filling Dewars should wear full length trousers/pants or full length apron, and footwear that covers the entire foot, along with goggles or face shield and cryo-gloves. Persons filling must be in constant attendance to the filling operation.

CHEMICALS (cont'd)

Mercury Handling and Spill Clean-up

Health Effects

The American Conference of Governmental Industrial Hygienists has established a threshold limit value (TLV) of 0.05 mg/m³, based on an 8-hour day and 40-hour week. The TLV for mercury also carries a "skin" notation, which indicates the potential contribution to the overall exposure by direct contact with the substance.

Metallic mercury can also be absorbed into the body by ingestion or inhalation. Mercury vapors are odorless, colorless, and tasteless. A quantity as small as 1 milliliter can evaporate over time, and raise levels in excess of allowable limits. Mercury poisoning from exposure by chronic inhalation produces a variety of symptoms including: (1) emotional disturbances, (2) unsteadiness, (3) inflammation of the mouth and gums, (4) general fatigue, (5) memory loss, and (6) headaches. In most cases of exposure by chronic inhalation, the symptoms of poisoning gradually disappear when the source of exposure is removed. Improvement, however, may be slow and complete recovery may take years.

Storage and Handling

Because of the health effects of mercury and the extremely difficult and time-consuming procedures required to properly clean spills, every effort should be taken to prevent accidents involving mercury. Always store mercury in unbreakable containers and store in a well-ventilated area. When breakage of instruments or apparatus containing mercury is a possibility, the equipment should be placed in an enameled or plastic tray or pan that can be cleaned easily and is large enough to contain the mercury. Transfers of mercury from one container to another should be carried out in a hood over a tray or pan to confine any spills.

IF AT ALL POSSIBLE, the use of mercury thermometers should be avoided. If a mercury thermometer is required, many are now available with a Teflon coating that will prevent shattering. Always wash hands after handling mercury to prevent skin absorption or irritation.

Air Monitoring

Any mercury spill has the potential to generate airborne concentrations in excess of regulated levels. Contact the MTU Occupational Safety and Health Office at 487-2118 for air monitoring of the spill area BEFORE cleanup to determine the airborne concentration. Large spills or spills with elevated vapor levels may dictate cleanup by a qualified contractor.

CHEMICALS (cont'd)

Protective Clothing

For small spills, a lab coat, safety glasses, and gloves should be used. Gloves made of the following have been rated as excellent for protection against elemental mercury: (1) chlorinated polyethylene (CPE), (2) Polyurethane, (3) Viton, (4) Butyl Rubber, (5) Polyvinyl Chloride (PVC), (6) Nitrile Rubber, (also known by several brand names), and (7) Neoprene. If mercury has been spilled on the floor, the workers involved in cleanup and decontamination should wear plastic shoe covers. The MTU Occupational Safety and Health Office should be called immediately if a spill is extensive enough to require workers to kneel or sit where mercury has been spilled since Tyvek or similar impermeable clothing will be required.

Cleanup of Spills

Special spill kits are available from a variety of sources. If a spill kit is purchased, follow the enclosed directions. Alternatively, a kit can be assembled with the following components:

1. Protective gloves
2. Mercury suction pump or disposable pipettes to recover small droplets.
3. Elemental zinc powder (or commercial amalgam material)
4. Dilute sulfuric acid (5-10%) in spray bottle
5. Sponge or tool to work amalgam
6. Plastic trash bag
7. Plastic container (for amalgam)
8. Plastic sealed vial for recovered mercury

Major Spills - Any spill more than 10 grams is a large spill and should not be cleaned up by laboratory personnel. Alert the neighbors and clear the area. Close the doors behind the area and do not allow reentry. Call MTU Public Safety at 1-2-3 for immediate assistance. A large spill will require the use of special respiratory protection.

Minor Spills

- A. Isolate the area so that the mercury cannot be tracked around. Spilled mercury can spread a very long way.
- B. Wearing protective clothing, pools and droplets of metallic mercury can be pushed together and then collected by a suction pump or disposable pipette. Very small amounts can be picked up with adhesive tape. Store recovered mercury in a sealed plastic vial labeled "Mercury".

CHEMICALS (cont'd)

- C. After the gross contamination has been removed, sprinkle the entire area with zinc powder. Spray the zinc with the dilute sulfuric acid. (Or apply a commercial powder according to manufacturer's directions).
- D. Using the sponge or other stiff tool, work the zinc powder/sulfuric acid into a paste consistency while scrubbing the contaminated surface and cracks or crevices. To minimize contamination of housekeeping items, stiff paper may be used to assist in cleaning up the amalgam. After the paste has dried, it can be swept up and placed into the plastic container for disposal.
- E. Paper towels, shoe covers, sponges, and anything used for the cleanup should be placed in the trash bag to be disposed of as contaminated material.
- F. Wash hands thoroughly.
- G. Contact MTU Occupational Safety and Health for information regarding the disposal of mercury clean-up materials.

CHEMICALS (cont'd)

Peroxides

Organic peroxides, such as peracetic acid and benzoyl peroxide, are potentially very hazardous due to their highly reactive nature and complex behavior. They are generally low-power explosives that are sensitive to shock, sparks, or other accidental ignition. They are also highly flammable.

The following recommendations for safe storage and use are suggested:

- a. Limit the quantity to the minimum amount required.
- b. Avoid exposure to shock, sparks and other forms of accidental detonation. They are also sensitive to heat, friction, impact, light, and to strong oxidizing and reducing agents.
- c. Do not use metal spatulas to handle peroxides. Contamination by metals can lead to explosive decomposition.
- d. Do not permit smoking, open flames, and other sources of heat near peroxides.
- e. Store peroxides at the lowest possible temperature consistent with their solubility. Do not freeze since this increases the shock and heat sensitivity.
- f. Do not store with or near acids.
- g. Clean up spills immediately. Solutions of peroxides can be absorbed on vermiculite or other absorbing material and disposed of using acceptable MTU disposal procedures.
- h. Do not use solutions of peroxides under conditions in which the solvent might be vaporized because this will increase the peroxide concentration in the solution.

The biggest hazard for many peroxide materials is due to the formation of unstable peroxide compounds, which may form under normal storage conditions. These peroxides may accumulate and may explode violently when subjected to thermal or mechanical shock. In some cases they may form under the threads of a container lid and may explode when the lid is unscrewed.

The table below lists the most common materials that form unstable peroxides. The first column lists the most hazardous materials that may explode without being concentrated. The second column lists compounds that are most hazardous when peroxide levels are concentrated, which may occur during distillation or evaporation. The last column is comprised of the vinyl monomers that may form peroxides that can initiate explosive polymerization of the bulk monomers.

The presence of any compound listed in the table is a warning that peroxides can form and a hazard exists. Peroxides in a solution at a concentration of up to 1% normally do not present a thermal or shock hazard. These solutions may be safely disposed of or treated to remove peroxides. Should crystals form in the peroxidizable liquid or discoloration occur in a peroxidizable solid, peroxidation may have occurred and the material should be considered extremely dangerous. In this instance the container must not be touched or moved and should only be opened remotely by professionals.

The degree of danger varies considerably with a compound's molecular structure. Peroxidation

CHEMICALS (cont'd)

of the following compounds pose the greatest risk of explosion:

- Ethers and acetals;
- Olefins (compounds with a single double bond) with hydrogen, chlorine, or fluorine atoms attached, terpenes, and tetrahydronaphthalene;
- Dienes and vinyl acetylenes;
- Vinyl monomers - including vinyl halides, acrylates, methacrylates and vinyl ethers.

Common compounds that form peroxides during storage. The list is not inclusive. The time period shown represents the maximum time period for storage for peroxide formation.

Three Months Peroxide Hazard on Storage	Twelve Months Peroxide Hazard on Concentration	Twelve Months Hazard due to Peroxide Initiation of Polymerization
<ul style="list-style-type: none">• Isopropyl ether• Divinyl acetylene• Vinylidene chloride• Sodium amide• Potassium metal	<ul style="list-style-type: none">• Ethyl ether• Tetrahydrofuran• Diazine• Methyl butyl dimethyl ether (diglyme)• Vinyl ethers• Dicyclopentadiene• Diacetylene• Methyl acetylene• Cumene• Tetrahydronaphthalene• Cyclohexene• Methylcyclopentane• Acetal	<ul style="list-style-type: none">• Styrene• Butadiene• Tetrafluoroethylene• Chlorotrifluoroethylene• Vinyl acetylene• Vinyl acetate• Vinyl chloride• Vinyl pyridine• Chlorobutadiene (chloroprene)

Reference source: chem-safety.com

CHEMICALS (cont'd)

Hydrochloric Acid

Substance	Hydrochloric acid (Muriatic acid) CAS 7647-01-0 CAS 7647-01-0	Hydrogen chloride
Formula	Reagent grade conc HCl contains 37 wt HCl % HCl in water; constant-boiling acid (an azeotrope with water) contains -20% HCl	
Physical Properties	Concentrated acid evolves HCl at 60 °C leading to the formation of an azeotrope of constant composition (20% HCl) bp 110°C, mp -24°C Miscible with water	bp -85°C, mp -114°C Miscible with water
Odor	Sharp, irritating odor detectable at 0.25	Sharp, irritating odor detectable to 10 ppm at 0.25 to 10 ppm
Vapor Density	1.27 (air = 1.0)	
Toxicity Data	LD ₅₀ oral (rabbit): 900 mg/kg LC ₅₀ inhal (rat): 3124 ppm (1 h) PEL (OSHA): 5 ppm (7 mg/m ³ ceiling) TLV (ACGIH): 5 ppm (7.5 mg/m ³ ceiling)	
Major Hazards	Highly corrosive; causes severe burns on eye and skin contact and upon inhalation of gas.	
Toxicity	<p>Hydrochloric acid and hydrogen chloride gas are highly corrosive substances that may cause severe burns upon contact with any body tissue. The aqueous acid and gas are strong eye irritants and lacrimators. Contact of conc hydrochloric acid or concentrated HCl vapor with the eyes may cause severe injury, resulting in permanent impairment of vision and possible blindness, and skin contact results in severe burns. Ingestion can cause severe burns of the mouth, throat, and gastrointestinal system and can be fatal. Inhalation of hydrogen chloride gas can cause severe irritation and injury to the upper respiratory tract and lungs, and exposure to high concentrations may cause death. HCl gas is regarded as having adequate warning properties.</p> <p>Hydrogen chloride has not been found to be carcinogenic or to show reproductive or developmental toxicity in humans.</p>	
Flammability and Explosibility	Noncombustible, but contact with metals may produce highly flammable hydrogen gas.	

CHEMICALS (cont'd)

Reactivity and the Incompatibility

Hydrochloric acid and hydrogen chloride react violently with many metals, with generation of highly flammable hydrogen gas, which may explode. Reaction with oxidizers such as permanganates, chlorates, chlorites, and hypochlorites may produce chlorine or bromine.

Storage and Handling

Splash goggles and rubber gloves should be worn when handling this acid, and containers of HCl should be stored in a well-ventilated location separated from incompatible metals. Water should never be added to HCl because splattering may result; always add acid to water. Containers of hydrochloric acid should be stored in secondary plastic trays to avoid corrosion of metal storage shelves due to drips or spills.

Cylinders of hydrogen chloride should be stored in cool, dry locations separated from alkali metals and other incompatible substances. Cylinders of compressed gas should be handled according to the procedures described elsewhere in this safety manual.

Accidents

In the event of skin contact, remove contaminated clothing and immediately wash with flowing water for at least 15 min. In case of eye contact, immediately wash with copious amounts of water for at least 15 min while holding the eyelids open. Seek medical attention. In case of ingestion, do not induce vomiting. Give large amounts of water or milk if available and transport to medical facility. In case of inhalation, remove to fresh air and seek medical attention.

Carefully neutralize spills of hydrochloric acid with a suitable agent such as powdered sodium bicarbonate, further dilute with absorbent material, place in an appropriate container, and dispose of properly. Dilution with water before applying the solid adsorbent may be an effective means of reducing exposure to hydrogen chloride vapor. Respiratory protection may be necessary in the event of a large spill or release in a confined area.

Leaks of HCl gas are evident from the formation of dense white fumes on contact with the atmosphere. Small leaks can be detected by holding an open container of concentrated ammonium hydroxide near the site of the suspected leak; dense white fumes confirm that a leak is present. In case of accidental release of hydrogen chloride gas, such as from a leaking cylinder or associated apparatus, evacuate the area and eliminate the source of the leak if this can be done safely. Remove cylinder to a fume hood or remote area if it cannot be shut off. Full respiratory protection and protective clothing may be required to deal with a hydrogen chloride release.

Disposal

In many localities, hydrochloric acid or the residue from a spill may be disposed of down the drain after appropriate dilution and neutralization. Otherwise, hydrochloric acid and waste material containing this substance should be placed in an appropriate container, clearly labeled, and handled according to your institution's waste disposal guidelines. Excess hydrogen chloride in cylinders should be returned to the manufacturer.

APPENDIX C. LABORATORY SIGNS

The following signs must be completed and posted on each laboratory door. Copies are available in the Chemical Engineering office.

This Workplace Covered

by the Michigan

Right To Know Law



Employers must make available for employees in a readily accessible manner, Material Safety Data Sheets (MSDS)* for those hazardous chemicals in their workplace.

Employees cannot be discharged or discriminated against for exercising their rights including the request for information on hazardous chemicals.

Employees must be notified and given direction (by employer posting) for locating Material Safety Data Sheets and the receipt of new or revised MSDS(S).

*Employees may also request MSDS from the Michigan Department of Consumer & Industry Services, Bureau of Safety & Regulation, Occupational Health Division, 7150 Harris Dr., PO Box 30649, Lansing, Michigan 48909-8149, (517) 322-1608.

BSR/CET #2105 (Rev. 3-02)



"Serving Michigan ... Serving You!"
Michigan Department of Consumer & Industry Services

MSDS(s) For This Workplace Are Located At

Location(s)

Location(s)

Person(s) responsible for MSDS(S)

Phone

To Be posted throughout the

MSDS(s)

Title

Receipt Date

Posting Date

Revises MSDS

[illegible]

Michigan Department of Consumer & Industry Services
Bureau of Safety & Regulation
Consultation Education & Training Division
7150 Harris Drive, P.O. Box 30643
Lansing, Michigan 48909-8143 (517) 322-1809

Paid in part with
federal OSHA funds.
BSR/CET #2106 (Re



APPENDIX D: EXIT FORM

To be completed prior to the student leaving the university.

GRADUATE STUDENT LABORATORY EXIT FORM

*To be completed by Graduate Students at the time they submit their
"Scheduling of Final Oral Examination Form" (M5 or D7)*

Name _____ Date _____

Degree _____

Thesis/Dissertation Title _____

My Research has been conducted in room(s) _____ Bldg(s) _____

For my Research Project I have used the following Chemicals and / or Equipment:

_____ I have properly disposed of all chemicals and returned appropriate equipment
used during the course of my research.

OR

_____ I have reassigned the chemicals and equipment to: _____

Signed by: **The approval page on your Thesis/Dissertation will not be signed by the
Department Chair until this form is complete.**

Student _____ Date _____

Advisor _____ Date _____

Mgr. Lab Facilities _____ Date _____

Dept. Chair _____ Date _____

APPENDIX E: SAFETY MANUAL REVISION LOG

- August 11, 2004: Replace JSA with revised JSA.
 Added JSA instructions.
 Added Hydrochloric Acid to Chemicals section
 D. A. Crawl
- September 29, 2004: Updated Required Clothing section for the general case for any exposed
 skin.
 D. A. Crawl
- May, 2008: Updated 911 emergency phone numbers to replace 1-2-3
 Major review and revision of entire manual - a lot of changes.
 D. A. Crawl