2014-15
SAFETY MANUAL
for use in
CM4110: UNIT OPERATIONS LABORATORY
and
CM4120: PLANT OPERATIONS L[illegible]ATORY

A.J. Pintar and D.W. Caspary

D[illegible]ment of Chemical Engineering
Michigan Technological University
Houghton, Michigan 49931

Last Update: August 19, 2014 by D.W. Caspary

This page intentionally left blank.

Emergency Response

All emergencies: **Dial 911** on any campus or cell phone.

- Report the nature and location of accident.
- Stay on the line with the dispatcher.
- Emergency personnel will be dispatched.
- Meet emergency personnel to assist in locating accident.

Important Phone Numbers

	Campus phone	Outside line
All Emergencies	911	911
Poison Control Center	8-1-800-562-9781	1-800-562-9781
MTU OSHS	7-2118	487-2118
Central Heating Plant	7-2707	487-2707
Chem Eng dept office	7-3132	487-3132

What To Do If Someone Is Hurt

1. Life Threatening Injury or Illness, 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 also notify Occupational Safety.

2. Non-Life Threatening Injuries or Illnesses that require immediate care:
   Students may use the Health Center at the SDC for all types of medical care.
   University employees must be treated at the Health Center for work-related injury or illness. Non-work related illnesses should be treated by your personal physician.
   Be sure to call University Health Services first, at 483-1860, 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.

Building or Lab Evacuation

All personnel are required to evacuate the Unit Operations Lab if the nitrogen alarm sounds.
All personnel are required to evacuate the building if the fire alarm sounds.
Evacuate the building using the stairs on ends of the hallways.
Emergency exits are denoted by lighted exit signs posted on the ceilings.
Do not use the elevators as a means of egress.
There are three exits from the Chemical Sciences and Engineering building:

- South end of the building on 1st floor;
- Northeast corner of the building between the 1st and basement;
- Middle of the hallway on 1st floor.

Note: The loading dock area is *not* an emergency exit.

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.

In the Event of a Fire in Unit Operations Lab

Use a safety shower to extinguish a clothing fire.
Shut down equipment if possible and if time permits.
Use the appropriate fire extinguisher to put out fire if this can be done without endangering yourself.
Evacuate laboratory immediately and safely.
Pull a fire alarm station (located at the ends of each hallway).
Evacuate the building using the above evacuation procedure.
Dial 911 on any phone.

Visible 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 911 on any phone.

Chemical Spills

Know the hazards associated with all chemicals used in the lab.

Know the location of spill response supplies and the procedure for containing any type of spill before operating any equipment or using any chemicals in UO Lab.

If a chemical is splashed on a person's skin, eyes, or clothing use the safety shower and/or eyewash fountain immediately and remove contaminated clothing.

Minor spills and large spills of non-hazardous chemicals must be cleaned up immediately following the specific handling procedures for the chemical.

In the event of a major spill or the spill of any hazardous chemical, notify the lab supervisor immediately. If you feel others may be in danger because of the spill: evacuate the building; close the doors to isolate the area; and then use any phone to dial 911.

Reporting all Incidents and Near Misses

Supervisors of injured employees must fill out an incident report form.

Injury of a student in class: the instructor must complete the form.

For 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.

After completing the MTU-required reporting, fill out a PAWS form.

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.

UNIT OPERATIONS LAB SAFETY RULES

1. The lab is open from 8 a.m. to 5 p.m. Monday through Friday for equipment review and other preparatory work. Equipment may only be operated and chemicals used during *scheduled lab times*. Written approval of the faculty advisor and the Laboratory Supervisor are required for anyone to be in the laboratory after hours (5 p.m. to 8 a.m.) or on weekends, or to operate equipment on non-scheduled lab days.

2. The team leader must know which team members are in the laboratory at any time. The team leader must sign the group in and out of the laboratory using the sign-in sheet just outside the laboratory office (Room B005A). For CM4120 the sign-in sheet will be located in room 107.

3. No equipment is to be operated, solutions prepared, or chemicals used until the approval of the instructor has been obtained at the check-in meeting *and* the group has passed the on-site safety check-in with the TA. Only the equipment pertaining to the assigned experiment is to be operated.
   A notebook attached to the experimental apparatus has a summary of key safety issues, the emergency shutdown procedure, and an operator's logbook. All members of a group are required to know this information as well as the safety aspects of surrounding experiments. The notebook must be signed by the team leader attesting to this level of safety awareness.

4. The JSA and all safety precautions must be followed at all times.

5. No operating equipment will be left unattended. At least two members of the group must be present while the equipment is operating. The group manager is responsible for making lunch and coffee break arrangements so that this rule is always satisfied.

6. All students are expected to be familiar with the safety aspects of all the chemicals used in the entire laboratory and with the coding system used to label containers and pipelines.

7. All chemicals must be transported in a safety carrier. All glass thermometers and more than one item of glassware must be transported in a bucket or other suitable container.

UNIT OPERATIONS LAB SAFETY RULES (CONT'D)

8. Chemicals and glassware are not to be transported on the spiral staircase. Only notebooks, calculators, pens and small tools are allowed to be carried on the spiral staircase with one hand free. The handrail must be used.

9. The laboratory floor must be kept dry, clean, and uncluttered at all times. Any spills should be cleaned up immediately. Mops, buckets, and squeegees are available in the storage room. Book bags, backpacks, coats and hats should not be stored in the laboratory.

10. Safety glasses with side shields or safety goggles (when handling hazardous chemicals), safety helmets, over-the-ankle non-porous safety shoes, a shirt, and long pants must be worn while working in the laboratory. Neckties, dangling clothing or jewelry, and other unsafe items are prohibited.

11. Sleeping is prohibited in the laboratory. Violation of this rule will result in dismissal from the laboratory for that day and an unexcused absence.

12. Horseplay of any sort is absolutely prohibited in the laboratory.

13. Eating, drinking, and chewing gum are prohibited in the laboratory.

14. Smoking and open flames are prohibited in the laboratory.

15. Using cell phones, media players, or other non-approved electronics is prohibited in the laboratory. Playing computer games or viewing non-lab related DVD's is prohibited in the laboratory and the control room.

16. Any accident or hazardous situation must be reported to the Laboratory Supervisor immediately.

A person who disregards safety rules will be called in for consultation. A penalty that suits the behavior may be imposed. Penalties may include a reduction in the course grade, or for serious or repeated violations, dismissal from the course.

This page intentionally left blank.

TABLE OF CONTENTS

TABLE OF CONTENTS, CONT'D

TABLE OF CONTENTS, CONT'D

This page intentionally left blank.

PREFACE

This safety manual is a part of the overall safety program in the Unit Operations Laboratory at Michigan Technological University. The main objective of this safety program is to protect students against adverse health effects or injury resulting from an unplanned event. The key to doing this is accident prevention. If the students follow the safety rules and guidelines presented in this manual, the possibility of an accident will be greatly reduced. In the event of an accident, any harmful effects will be minimized by knowledge of the emergency and first aid procedures as presented in the following pages.

A second objective of the safety program in the Unit Operations Laboratory is preparation for industrial safety. The Occupational Safety and Health Act (OSHA) at the federal level, MIOSHA (in Michigan), the Federal Hazard Communication Standard, the Michigan Right to Know Law, SARA Title III (Community Right to Know), OSHA's Process Safety Management of Hazardous Chemicals (PSM) and EPA's Risk Management Program (RMP) have had tremendous impact on the chemical industry and on how chemical engineers perform their jobs. It is hoped that this safety manual will help our students develop the proper attitude towards safety so that an awareness of safety permeates all aspects of their private lives and professional careers. There is no reason for another "Bhopal Disaster" to occur.

This safety manual is intended to serve as the primary safety reference for the Unit Operations Laboratory course. This manual presents the major points on safety. The students are also expected to consult the Material Safety Data Sheets (MSDS) and other safety references for specific details.

The original safety manual was written by Michael W. Radelt (Manager), Karen Brooks, Scott Garthwaite, and Shawn Wrubel in 1983. From 1983 through spring 2001 improvements to the organization and scope of the safety manual have been suggested by numerous students, CM faculty, and others. The efforts of these concerned individuals have helped to shape our safety program into the successful program as it exists today.

Anton J. Pintar
August, 2001

Beginning in spring 2001, reviews and updates of the safety manual are performed on a continuous basis through feedback from the Safety Committee and class discussion in regularly scheduled Safety Meetings. The results of each year's activities are compiled by a PAWS review team, documented in a formal report, and submitted to the lab supervisor for incorporation into the safety program. Safety information and rules are constantly updated to reflect current practices. The 2014-15 version of the Safety Manual includes feedback from the spring 2014 annual PAWS program review and student surveys.

David Caspary
August, 2014

This page intentionally left blank.

A. INTRODUCTION

The objective of this safety manual is to provide sufficient information to the students in the Unit Operations Laboratory so that they will follow safe procedures for operating equipment, use proper procedures in handling chemicals, and be prepared to deal with any emergency situations that may arise. It is absolutely essential that the students be thoroughly familiar with the material in this safety manual before starting any experimental work in the laboratory.

This manual contains information on:

- policies, procedures, rules and regulations that must be followed;
- the safety precautions for each of the experiments in the laboratory;
- the potential hazards of the chemicals used;
- proper procedures for operating equipment in the laboratory;
- proper use of the safety equipment;
- emergency procedures and first aid.

B. PREVENT ACCIDENTS WITH *S*AFETY – THE "PAWS" PROGRAM

A comprehensive safety program requires constant vigilance, continuous training, c[illegible] but prudent incident reporting, and systems to measure and document safety performanc[illegible] activities must be executed with an eye toward critical revie[illegible]uous improvement. In a course such as Unit Operations Lab, some safety responsibili[illegible]are b[illegible]assumed by the instructional staff (introductory safety training, orientation, te[illegible]ersight) while all other safety responsibilities are best assumed by the students themsel[illegible].

The PAWS safety program was initiated during the Spring Quarter, 1989. The name of the program was suggested by Elizabeth A. Vary, a 1988-89 student in the Unit Operations Laboratory. Various aspects of the program were suggested by other studen[illegible]lass of 1989. The program is a combination of features used in the SOAR (Stop, Observ[illegible] Ac[illegible] Report) program at the BASF Corporation and the Praise Positive Program at the Dow [illegible]l Company.

The PAWS program provides t[illegible]k to develop a culture of safety – a safety community – within the laboratory. The key to t[illegible]PA[illegible]rogram is that the students in the Unit Operations Laboratory bear the responsibilit[illegible]r own health and safety and for the safety of those around them. Specific safety-related respons[illegible]ties are assigned to the students in addition to their course responsibilities. The student-owned portion of the PAWS program is built upon a *Safety Committee* and a *Communications and Documentation System*.

1. Safety Committee

Each engineering tea[illegible] *Safety Coordinator* who will take a special interest in hazards identificatio[illegible]tion/mitigation and in the safe operation of the team's laboratory experiment. Collective[illegible]sa[illegible]y coordinators during each experiment cycle will form the S[illegible]*mmittee*. The safety committee consists of one or two Safety Committee Leaders, [illegible]ral [illegible]fety Meeting Presenters, a number of Lab Inspectors, Special Topic Researchers, and [illegible]bulator. The roles and responsibilities of each are defined below.

Safety Coordinator – There will be one Safety Coordinator for each engineering team. The Safety Coordinator will spend considerable effort in developing the Job Safety Assessment (JSA) for the experiment and will educate the other team members of the safety concerns for the team's assigned experiment. During lab days, the team's Safety Coordinator will keep a watchful eye on team activities and will act as a safety resource to the team.
Each person in the team will assume the role of safety coordinator once per semester. In addition to the responsibility toward their team, the safety coordinator will also assume the role of Safety Committee Leader, Safety Meeting Presenter, PAWS Tabulator, Special Topic Researcher, or Lab Inspector.

Safety Committee Leader – The Safety Committee Leader will coordinate all activities of the safety committee. As safety committee leaders they will ensure that all safety committee responsibilities are fulfilled on lab days. Additionally, they will test random groups on their emergency shut-down procedures at some point during the run day. There will be one safety committee leader for each section.
The two Safety Committee Leaders will work together to coordinate a single safety meeting for both laboratory sections at the scheduled time.

Safety Meeting Presenter – The Safety Meeting Presenter will be responsible for preparing and delivering the presentation and facilitating class discussion at the safety meeting. The responsibility may be distributed amongst several dynamic, charismatic individuals who will engage the class in stimulating and productive discussion at the safety meeting.

PAWS Tabulator – The PAWS tabulator will review any new PAWS reports, follow up on any open PAWS reports from previous experiment cycles, and help maintain the PAWS tracking web site and report this to the entire class at the safety meeting.

Special Topic Researcher – The Safety Committee will be asked to present one or more safety topics related to lab operations or chemical process safety at the next safety meeting. The Special Topic Researcher will research and present the information.

Lab Inspector – The Lab Inspectors will be responsible for inspecting the UO Lab facilities and equipment before each scheduled day of laboratory work. They will use the Safety Inspection Checklist (SIC) to inspect all lab equipment, safety equipment, storage areas, and lab facilities.

2. The PAWS Communication and Documentation System

An effective safety program requires open communications between all affected people. The PAWS program includes a reporting system to document all unsafe situations or describe any safety suggestions. The individual reports are tabulated and summarily reported to the entire group in regular safety meetings for discussion and resolution. Permanent records are maintained of all reports and communications as well as the minutes and attendance at safety meetings.

a. PAWS Incident Report Forms – A student observing an unsafe act or condition is expected to correct the situation before an accident occurs. After correcting the problem, a PAWS Incident Report Form is filled out and submitted to the Laboratory Supervisor. (Blank forms are available throughout the Unit Operations Laboratory and through the PAWS web page http://www.mtu.edu/chemical/facilities/safety/PAWS_incident_report.pdf) The identity of

the "perpetrator" of the unsafe act is not important and is not indicated on the PAWS Incident Report Form. A PAWS Form is also submitted for accidents, "near misses," major spills, laboratory evacuations, and for safety suggestions. The student submitting a PAWS report will receive a safety incentive point for correcting and reporting the problem. The students accumulating the most points in each laboratory section at the end of the semester will receive an incentive award.

b. The Safety Meeting – A Safety Meeting will be scheduled toward the end of each experiment cycle. All students are required to attend all safety meetings and must sign a document attesting to their presence.

A safety meeting consists of the following agenda:

i. A review and discussion of (and resolution of open) PAWS Forms that were submitted during this experiment cycle, including PAWS forms that are still open from prior experiment cycles;
ii. A review and discussion of the laboratory inspections as reported on the SIC;
iii. Discussion of any safety incidents that occurred in the lab;
iv. Presentation on an appropriate or assigned safety related topic or safety training;
v. General Discussion. Open comments from each team on safety or operational concerns with the experiment they just operated. The Safety Committee should bring additional PAWS forms to the Safety Meeting to document any safety suggestions or previously unreported incidents.

At the end of the Safety Meeting, an electronic copy of the slide presentation will be posted to the course web page.

Additional information on the PAWS program is available on the web at http://www.mtu.edu/chemical/facilities/safety/accident-prevention/ The PAWS website contains links to a PAWS Tracking System, a PAWS Incident report form, and a template of the Job Safety Assessment form.

REMEMBER: The goal of the PAWS program is accident prevention. We will work diligently together to protect the health and safety of all people in the Unit Operations Laboratory and in the environment we share!

C. OSHA and MIOSHA REGULATIONS

Several laws and regulations affect our laboratory and work practices.

1. The Michigan Right-To-Know Law

The objective of the Michigan Right To Know Law is to inform employees of the potential adverse health and safety effects of chemicals used in the workplace. The Michigan Right To Know Law requires an employer to provide this information to employees. This law, which went into effect at Michigan Technological University on February 25, 1987, incorporates the Federal Hazard Communication Standard (OSHA 29 CFR 1910.1200, Aug., 1987) into the Michigan Occupational Safety and Health Act (MIOSHA) and has additional requirements on labeling containers and pipelines holding hazardous chemicals. Although the Right to Know Law specifically applies to employees, the students in the Unit Operations Laboratory are considered to be employees for the purposes of this law.

As applied to the Unit Operations Laboratory, the Michigan Right to Know Law requires:

a. Identification of both containers and pipelines holding hazardous chemicals. Unlabeled and unknown containers of chemicals and chemicals without an MSDS (see below) must be considered to be a hazardous chemical. (Note that this is equivalent to requiring that all containers and pipelines holding even innocuous chemicals must be labeled).
b. A Material Safety Data Sheet (MSDS) must be available to the employees for each hazardous chemical in the workplace. The MSDS contains information on the health and safety hazards (health effects, fire hazards, and reactivity) of the chemical, proper handling procedures, protective equipment required for safe handling of the chemical, and first aid and spill procedures.
c. An employee training program. This must include information on the Michigan Right To Know Law and on an employee's rights under the law, a list of the hazardous chemicals used in the workplace, the location of the MSDS's, and training in proper procedures and in the use of proper equipment for handling hazardous chemicals.

The Unit Operations Laboratory at Michigan Technological University is in compliance with the Michigan Right To Know Law:

a. All containers and pipelines in the laboratory have been labeled. The labels use a code to indicate the health hazards, fire hazards, reactivity, and required protective equipment for the chemical in question. The coding system is explained on charts located at several places in the laboratory. Each student is expected to be familiar with the coding system. It is the user's responsibility to label new containers of chemicals as they are brought into the laboratory.
b. The MSDS's for all the hazardous chemicals used in the laboratory are located on the wall opposite the office of the Unit Operations Laboratory (Room B005A, Chemical Sciences and Engineering Building). The MSDS's for the chemicals used in the RSST experiment are located in Room 207 along with MSDS's for other chemicals present in Room 207.
c. No new chemicals may be brought into the laboratory until MSDS's are posted and all affected students and employees are notified and properly trained.
d. This safety manual is a part of both the training program and the Written Hazards Communications Program required by the Right To Know Law. Information on hazardous chemicals, including their adverse effects and location in the laboratory, is included in this safety manual.
e. The coding system used on containers and pipelines will also be explained at the beginning of the fall semester. Students are expected to be familiar with the Lab Safety Supply labeling system, the NFPA "diamond" labeling system, and the Hazardous Materials Identification System (HMIS).

2. Management of Change Procedures

A Change Management Program is required under the Process Safety Management of Hazardous Chemicals Standard or PSM (OSHA 29 CFR 1910.119, March, 1992). The Management of Change portion of PSM [OSHA 29 CFR 1910.119(l)] requires thoughtful consideration and review before any change is implemented in a chemical process. The catastrophe at Flixborough, England is one of the reasons for this legal requirement. As a part of the Management of Change requirements an "employer shall establish and implement written procedures to manage changes (except for in-kind replacement) to process chemicals, technology, equipment, and procedures; and changes to facilities that affect a covered process."

The Michigan Technological University Unit Operations Laboratory Management of Change Policy requires the completion of a form (available from the Manager of Laboratory Facilities) that provides specific information on the requested change. The form is submitted to the Manager of Laboratory Facilities for evaluation. A minor change can be approved immediately. A major change will require committee review and approval. Plan ahead if your experimental objectives require changes that are covered by the Management of Change Policy. Get a copy of the form and begin compiling the necessary supporting documentation.

3. Equipment *Lock-Tag-Try* Procedures

The objective of a formal Lock-Tag-Try Procedure is to eliminate accidents resulting from inadvertent activation of equipment during normal operations or maintenance work. For the purposes of the OSHA regulations on Control of Hazardous Energy Sources - 29 CFR 1910.147, Sept., 1990, students in the Unit Operations Laboratory will be considered "affected employees" and will be trained to be familiar with and to adhere to the Maintenance Lock-Tag-Try Procedures used in the laboratory.

The Lock-Tag-Try policies require deactivating the system to bring it to a "zero energy state". Each operations and maintenance person is required to lock out (or block out) and place a name tag on each energy source, then test it before performing a procedure that might endanger themselves or others.

All ***maintenance*** work in the Unit Operations Laboratory will be carried out only by Michigan Tech employees (faculty, laboratory supervisor, or maintenance personnel) or by students under the direct supervision of a Michigan Tech employee. It is the responsibility of the Michigan Tech employee to know and follow the ***Maintenance Lock-Tag-Try Procedures*** prior to beginning the maintenance work. Students are not to remove locks or tags being used as a part of the Maintenance Lock-Out.

MAINTENANCE LOCK-TAG-TRY PROCEDURE (June 6, 2007)
1. All maintenance personnel are to be provided with a good lock. The lock will have the worker's first and last initials painted on the lock. The individual whose initials are on the lock and their immediate supervisor will have the only keys to that lock. This lock is to be used only for locking out machinery.
2. The worker will check that no one is operating the machinery before turning off the power. The worker will notify immediately the faculty/staff member responsible for that piece of equipment.
3. All energy sources which could activate the machine will be locked out.
4. All steam, water, air, process fluids, and hydraulic lines must be bled to completely remove the fluid and pressure in the lines and in reservoir tanks.
5. Any mechanism under tension or pressure such as springs should be released and blocked.
6. When working on equipment such as power presses, the ram is to be blocked or pinned so that it cannot fall. Lower the weight onto the blocking before starting maintenance procedures.
7. The main valve or main electrical disconnect must be locked out and tested to be sure that the energy source to the machine is off.
8. Electrical circuits are to be checked with properly calibrated electrical testing equipment. Stored energy in electrical capacitors must be safely discharged.

9. Each person working on the machinery must put a lock on the machine's lockout device. Any machine not having an appropriate lockout point will first be fitted with an appropriate device and then locked out before any maintenance is performed.
10. A lockout tag will accompany each worker's lock showing the time, date, and person's name.
11. The lock and tag will be removed as soon as that employee is done with their work on that piece of equipment.

Certain ***operational*** procedures also require equipment lock-outs. For example, cleaning of the size reduction equipment in the Comminution experiment requires that the crusher be off and that the power supply to the crusher be locked out before inserting hands or tools into the machine. Students are permitted to perform these types of activities following the ***Operations Lock-Tag-Try Procedure***. Students will be trained in and expected to follow the Operations Lock-Tag-Try Procedure.

OPERATIONS LOCK-TAG-TRY PROCEDURE (June 6, 2007)

1. Sign out a numbered lock and key from the lock board in the Unit Operations Laboratory. The individual who signs out the lock and key must maintain possession of the key.
2. Get a tag from the lock board and write your name, the date, and the reason for locking out the equipment on the tag.
3. Lock the appropriate power switch in the OFF position. In some lock-out cases it may also be necessary to bleed pressure from lines and tanks, to drain lines, to lock out valves, and to use blocks in order to prevent movement.
4. Check to make sure that all locked out devices cannot be activated and the energy source is completely disabled and cannot be reactivated before the lock is removed.
5. Tag the lock with the tag that you prepared in step #2.
6. Perform the operation planned.
7. Remove the tag and lock.
8. Sign the lock and key back in and return the lock and key to the lock board. Discard the tag.

Some maintenance and operational procedures must be performed while the equipment is running. An example is adjusting the packing gland on a centrifugal pump. This must be done while the shaft is turning. These maintenance procedures should be performed only under the direct supervision of a university employee.

D. Personal Protective Equipment

1. Required Clothing

a. Long pants.
b. No neckties, no dangling clothes, parts of clothing, key fobs, or jewelry.
c. Shoulders, upper arms, and the entire torso must be covered at all times.
d. Buttoned long sleeve shirts are required for Shell and Tube Heat Exchanger, and when handling chemicals that can burn the skin or be absorbed through the skin. Keep a long-sleeved shirt in your locker so that it is available on lab days.
e. Precautions must be taken to prevent long hair from becoming entangled in moving machine parts. Hair that falls below shoulder length needs to be tied up and tucked under the hardhat.

2. Footwear

a. All persons operating equipment in the Unit Operations Laboratory are required to wear over-the-ankle, non-porous shoes with toe protection that meets any of the ANSI Z41-1999, ASTM F-2412-2005, or ASTM F-2413-2005 compliance standards. This requirement can be fulfilled by purchasing safety shoes or by using appropriate strap-on toecaps.
b. Proper footwear is required to protect the feet against burns from chemicals, steam, and hot water and from the impact of heavy falling objects such as tools or barrels.
c. Safety footwear can be purchased from most shoe stores, any of the discount stores, or over the Internet.

3. Eye Protection

a. Safety glasses with side shields or safety goggles are to be worn at all times in the laboratory.
b. Safety goggles must be worn when handling hazardous chemicals.
c. Glasses and goggles must comply with ANSI Z87.1-2003.
d. Anyone wearing contact lenses in the laboratory must indicate this with a red dot on the safety glasses.
e. Eye protection protects the eyes against flying objects, irritant chemicals, and chemical dust.
f. Eye protection can be purchased from Chem Stores, room B002 Chem Sci building.

4. Hardhat

a. A hardhat is to be worn at all times in B005, 105, and 213.
b. Hardhats provide protection from falling objects and from striking the head against pipes and equipment.
c. Hardhats must comply with ANSI Z89.1-2009 (Class A or B).
d. Hardhats are available at Chem Stores.

5. Gloves

a. Insulated gloves are required to avoid burns when operating steam valves and when handling hot objects.
b. Rubber or other protective gloves are required to avoid contact with chemicals that can burn or penetrate the skin.
c. A selection of gloves is available in the lab office.

6. **Rubber Aprons**
   a. Rubber aprons are required when handling concentrated acids or bases.
   b. Rubber aprons are required for transferring glacial acetic acid into the liquid-liquid extraction feed tank and for adding chemicals to the pilot-scale PDMS reactor system.
   c. Rubber aprons are stored near the liquid-liquid extraction column, in the lab office, and on the first floor by the flammable liquids storage cabinets.

7. **Ear Protection**
   a. Ear plugs are required when operating the Ro-Tap classifiers and the crushers.
   b. If your ears are sensitive to noise, you may want to wear ear plugs while working in other parts of the laboratory.
   c. Ear plugs protect the ears against high-decibel noise.
   d. Ear plugs are available in the lab office.

8. **Dust Mask**
   a. Dust masks are required when operating the crushers.
   b. A dust mask should be worn when handling powdery solids.
   c. Dust masks prevent inhalation of solid particles.
   d. Dust masks are available in the lab office.

9. **Face Shields**
   a. Face shields provide protection from splashing chemicals.
   b. Face shields are required when certain operations call for additional protection.
   c. A face shield mounted on a hardhat is stored near the catalyst adding station on the first floor of the UO Lab.

E. General Laboratory Safety

1. **Personal Hygiene Practices**
   a. Wash hands before and after running an experiment.
   b. Wear gloves appropriate for the experiment. Clean the gloves after using them.
   c. Cover any cuts or open wounds with clean, suitable material.
   d. Do not apply cosmetics while in the laboratory.
   e. Keep extra clothing in your locker so that you can change after working in the laboratory or in case your clothes become contaminated.
   f. Use a pipette bulb; do not use your mouth to pipette.

2. **Chemical Safety**
   a. Safety carriers are available in B005B near the chemical cabinet.
   b. Transport all chemicals using a safety carrier. The chemical must be in a closed container.
   c. No chemicals are to be carried on the spiral staircase. Use the elevators or North or South stairways.
   d. Flammable, volatile chemicals are to be stored in a Flammable Liquids Storage Cabinet.
   e. Chemicals are NOT to be stored in the hoods. Chemicals must be removed from the hoods at the end of the day.
   f. Use a Class B Fire Extinguisher for chemical fires.

g. Wear appropriate protective gear when handling strong acids and bases – should include goggles, apron, gloves, and face shield depending on specific hazards of the chemical.
h. Safe transfer of flammable liquids:
    i. Use a grounding strap when transferring flammable chemicals from an electrically conductive container into another electrically conductive container or tank.
    ii. Minimize the free-fall of liquids when making a transfer.
i. The Laboratory Supervisor must be notified of any new chemical introduced into the laboratory so that the MSDS can be obtained and all students can be trained on the handling of the chemical.

3. Chemical Labeling

a. ALL containers with chemicals must be properly labeled.
b. Label must list the contents and must have all hazardous characteristics identified. An NFPA or HMIS diamond is preferred.
c. Any chemical in an unlabelled container must be reported to the Laboratory Supervisor and treated as a hazardous substance until identified.
d. A current copy of the MSDS must be on file in the binder.

4. Chemical Storage Cabinet in Room B005B

a. No flammable, volatile chemicals are to be stored in room B005B.
b. Store acids and bases on the lowest shelf, acids on one side, bases on the other side.
c. Store oxidizable materials away from acids and bases.
d. Only chemicals listed on the door of the cabinet may be stored in the cabinet.
e. The Laboratory Supervisor must be notified of any new chemical placed in the chemical storage cabinet so that the MSDS can be obtained and the chemical list updated.

5. Flammable Liquids Storage Cabinets

a. Only flammable chemicals should be stored here.
b. Separate non-compatible chemicals.
c. Only chemicals listed on the door of the cabinet may be stored in the cabinet.
d. The Laboratory Supervisor must be notified of any new chemical added to the Flammable Liquids Storage Cabinet so that the MSDS can be obtained and the list updated.
e. Located on the basement level and on the first floor.

6. Flammable Waste Container

a. Solid flammable waste should be disposed of in the Flammable Waste Container.
b. Located on the basement level near the Spiral Staircase.

7. Electrical Safety

a. Use the “left-hand” rule in operating power boxes, i.e. use the left hand to move the handle up or down.
b. Power must be off before making electrical connections.
c. Avoid splashing or spraying water on electrical connections, wall sockets, lights, 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 for fires involving electrical equipment.

8. Glassware

a. Glassware is not to be transported up or down the spiral staircase. Use the elevators or stairways.
b. Glassware and glass thermometers must be transported in a bucket or suitable container.
c. Use hand protection when inserting glass tubing into rubber stoppers, corks, or rubber tubing.
d. Glass tubing should be fire polished and lubricated before insertion into rubber stoppers or rubber tubing.
e. Always wear eye protection when using glassware.
f. Take care in storing and in handling glassware.
g. Discard or replace damaged glassware.
h. Use only vacuum designed glassware for vacuum purposes.
i. Dispose of broken glass in the broken glass container.
j. For disposal of *unbroken* glassware or reagent bottles, rinse clean with tap water, destroy label, and place in cardboard box in hallway for pickup.

9. Safe Lifting Practices

a. Clear a pathway before moving things.
b. Check the object's weight to see if help is needed.
c. Keep your back straight and vertical to the ground. Keeping your head up and looking straight ahead will help.
d. Bend knees when lifting; use the legs to lift and not the back.
e. Bring the object as close to the body as possible.
f. When turning, turn the whole body. Do not twist your back while lifting or carrying.
g. Be careful when putting the object down; follow the same guidelines as for lifting.

10. Radios, Cell Phones, Media Players, and Computer Games

a. Using cell phones, media players, etc. is prohibited in the laboratory.
b. Playing computer games or viewing non-lab related DVD's is prohibited in the laboratory and the control room.

11. International Students

a. Students whose native language is not English, or who come from different cultural and political backgrounds may not have the same safety awareness levels as students who come from U.S. schools in the Great Lakes region.
b. Engineering teams must identify any team member(s) who may need additional assistance with safety-related issues. The team is responsible for the safety of all members of the team and will provide assistance as needed.

F. SAFE USE OF EQUIPMENT

1. Electric Drying Oven

a. Do not dry volatile flammable chemicals in the drying oven.
b. Do not place liquid thermometers in the oven.

2. Gas Cylinders

a. Cylinder contents are under pressure; keep cylinders upright and secured to a sturdy base with a chain or strap.
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.
e. Store cylinders away from high temperatures.
f. Do not store flammable materials near oxygen cylinders.
g. Always move a cylinder tank with a cart; cylinder must be chained to the cart and valve cover screwed on.
h. Install a point-of-use shut-off valve in the gas delivery piping line.
i. Have the Laboratory Supervisor or maintenance personnel change cylinders.
j. Once the cylinder is installed:
    i. Make sure all connections are tight and in good condition to prevent leakage.
    ii. Check for leaks with soapy water.
k. Fully open main cylinder valve while gas is in use.
l. Use the correct pressure regulator for the cylinder and gas.

3. Pumps, Fans, Compressors, and Blowers

a. Make sure that guards on moving parts and on electrical connections are in place.
b. Keep clothing, hands, and hair away from moving parts.

4. Mixing and Stirring Devices

a. Keep hands, hair, and loose clothing away from agitator.
b. For hand-held agitators, make sure agitator is off before adding material to the tank.
c. Make sure the agitator is immersed in the solution to be mixed before starting motor.
d. Turn off motor before removing the agitator from the mixed solution.

5. Ro-Tap Screening Apparatus

a. Located in rooms B005B ChemSci & 104 M&M.
b. Do not load the sieves until after the Ro-Tap has been adjusted.
c. If the Ro-Tap machines have to be adjusted for the number of trays, have one person hold the stack of trays while the other person adjusts the locknut.
d. Stay clear of the Ro-Tap while it is operating.
e. Wear earplugs while in the Ro-Tap room when the Ro-Tap is operating.
f. Minimize the amount of time spent in the Ro-Tap room when the Ro-Tap is operating.

6. **Steam Lines and Condensate Lines**
   a. Use insulated gloves for operating steam valves.
   b. Open valves slowly and only to the desired amount.
   c. Keep hands and clothing away from steam lines.
   d. Lines from steam traps should extend into the drain.
   e. During initial start up, by-pass steam traps until live steam exits from discharge line.
   f. Stay clear of condensate/steam discharge lines, especially during initial start up.
   g. After closing a main steam valve, wait 15 minutes and then re-close the valve.

7. **Ladders**
   a. Ladders are always to be chained when not in use. When one or more ladders are in use, the remaining ladders should be chained.
   b. Do not use the top two steps and do not lean while using a ladder. Someone should hold the base of the ladder to help stabilize the ladder.
   c. Always maintain three points of contact while ascending/descending a ladder.
   d. Moving ladders longer than 6 feet requires two people. Avoid lights and electrical wires while moving a ladder.
   e. Do not use the 12-ft stepladder.

8. **Manometers**
   a. The by-pass valve must be open before opening valves in lines to manometer legs.
   b. Open valve to the low pressure source first and then the valve to the high pressure source.
   c. Close the by-pass valve slowly and observe manometer reading. If manometer level is going off-scale, quickly open the by-pass valve.
   d. Open the by-pass valve immediately after taking the reading.
   e. Close the valve to the high pressure source first and then the valve to the low pressure source.
   f. In the event of a mercury spill, contact the Laboratory Supervisor. Follow the instructions and properly dispose of the waste.

G. Safety Equipment and Supplies

1. Eye-Wash Fountains

When to 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
-Test before every lab day. Allow water to run until clear to flush out piping.
-The person performing the test should initial and date the tag. When the tag is full, replace it with a new one from the lab office.

Location

-B003:	South side of lab
-B005:	East wall by both exit doors, (2)
-First Floor:	East wall by both exit doors and northwest corner, (3)
-Room 205, 209:	East wall near hallway exit door, (1) per lab

2. Safety Showers

When to Use
-Splashing or spilling chemicals onto someone.
-Clothing fires.

Operation
-Pull handle suspended beside the shower.
-The quick acting valve will deluge the victim with water.
-Clothing should be removed for a major spill.

Maintenance
-Test before every lab day. Allow water to run until clear to flush out piping.
-The person performing the test should initial and date the tag. When the tag is full, replace it with a new one from the lab office.

Location

-B003:	South side of lab
-B005:	East wall by both exit doors, (2)
-First Floor:	East wall by both exit doors and northwest corner, (3)
-Room 205, 209:	East wall near hallway exit door, (1) per lab

3. Fire Extinguishers

Operation

-Remove from wall and remember the acronym ***PASS***

Pull the pin.

Aim at the base of flames.

Squeeze the handle.

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

Types

-All fire extinguishers in the Laboratory are Class ABC.
-Class A - Wood, cloth, paper, and/or rubber fires.
-Class B - Gas, liquid, and grease fires.
-Class C - Fires involving energized electrical systems.

Location

-B003:	East wall on north side of main door
	East wall outside door to B003A
-B005:	East wall near each exit to hallway, (2)
	On wall outside Storage Room B005B, (1)
-105:	East wall near each exit to hallway, (2)
	West wall near Fixed Bed Reactor
	West wall, between SRU and Reactor Unit
-107	Near hallway door of PSCC Control Room, Room 107
-213:	East wall near hallway exit door
-205:	East wall near hallway exit door
-209:	East wall near hallway exit door

4. First Aid Kits

There are a variety of first aid kits in the labs. Some of the more extensive kits contain:

Red Cross Approved Bandages	Scissors
Red Cross Gauze	Johnson & Johnson First Aid Cream
Red Cross Cotton	Tweezers
Band-Aid Brand Clear Tape	Red Cross Adhesive Tape
Steri-pad Sterile Gauze Pads	Johnson & Johnson Triangular Bandage
Band-Aid Brand Sheer Strips	Latex Gloves
Paper Cups	Syrup of Ipecac
Amoply Ammonia Inhalants	Granulated Charcoal
Tongue Depressors	Epsom Salts
Sterile Eye Pads	First Aid Guide Booklet
Johnson's Cotton Buds	Pencil and Pad of Paper

Location

-Basement:	Across from office on the wall
-First Floor:	East wall by South exit door
-Room 205:	On wall near hallway exit door
-Room 209:	On wall near hallway exit door
-Room 213:	On wall near hallway exit door

5. Low Oxygen Alarm

Purpose

-With the nitrogen generator in continuous operation, a leak could result in an asphyxiating atmosphere in B005 or 105.

Operation

-Alarm will automatically go off if oxygen level falls below 19 volume-%.
-A continuous bell will sound and a red light will flash.
-The alarm is detectable throughout the laboratory but will not be audible throughout the building.

Location of Oxygen Analyzers

-Basement: Above the PDMS Reactor
Above the nitrogen generator

6. Drain Plugs

When to Use

-In the event of a major spill of a hazardous chemical to prevent the spill from getting into the sanitary line.

Operation

-Insert into floor drains.

Location

-Basement: North end near PDMS Reactor
East wall near North exit door
South end near Vacuum Drying

7. Fire Alarms

When to Use

-In the event of a fire, chemical release, or other emergency requiring building-wide evacuation.

Operation

-Pull the red handle.

Location

-On the wall *out in the hallways* near the stairwells.

8. Spill Clean-up Equipment

Purpose

-Contain and clean chemical spills.

Types

-Spill Dams (spill dikes, spill pillows, and spill socks)
-Solid Absorbent
-Sodium Bicarbonate

When to Use

-Spill dams keep major spills of hazardous chemicals from getting into the drains. Build a dike to contain the spill.
-Solid absorbent absorbs spilled hazardous liquid chemicals. Cover the spilled chemical with solid absorbent (neutralize acids and bases with sodium bicarbonate first) and then sweep up the absorbent and dispose as appropriate for the spilled chemical.
-Sodium bicarbonate neutralizes spilled acids and bases. Sprinkle sodium bicarbonate on the spilled acid or base and then dispose of the spill as appropriate for the spilled chemical.
-Spill supplies are not to be used for water or condensate. Use mops, buckets, and/or squeegees for water spills.

Location

-Spill Dams:	Near liquid-liquid extraction (basement) Across from PDMS Reactor (east wall basement level) Near northeast door (first floor)
-Solid Absorbent:	Near liquid-liquid extraction (basement) Near northeast door (first floor)
-Sodium Bicarbonate:	Chemical storage cabinet (Room B005B)

H. POSSIBLE ACCIDENTS

1. **Burns - 1st Degree**

   Source
   -Light contact with hot objects.
   -Scalding by 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.

   Healing
   -Will not cause scarring and will heal on its own.

   Treatment
   -Area should be coated with antiseptic ointment from the First Aid Kit.
   -Medical treatment may be necessary.

2. **Burns - 2nd Degree**

   Source
   -Contact with hot surfaces, hot liquids or with steam.
   -Flash burns from flammable liquids.
   -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.

   Healing
   -Causes little scarring.

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

3. 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 determine extent of tissue destruction.

Healing
-Can never heal by itself.
-Requires the best medical care.

Treatment
-DO NOT remove adhered particles of charred clothing.
-DO NOT apply ointment, commercial preparations, grease, or any home remedy.
-Cover burns with thick, sterile dressing or a freshly laundered sheet or other household linen.
-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, maintain an open airway.
-DO NOT immerse an extensively burned area or apply ice water to 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.
-Arrange for immediate medical attention.
-Transport to the hospital.

4. 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.

Treatment
-Use the Safety Shower.
-IMMEDIATELY remove all contaminated clothing, while under the safety shower.
-Thoroughly drench with water for 15-20 minutes.
-Flood acid burn with a dilute solution of bicarbonate soda.
-Flood alkali burn with a dilute solution of vinegar.
-Get medical treatment immediately.

5. Chemical Burns - Eyes

Treatment

-Use Eye Wash Fountain
-Remove contact lenses if present.
-Thoroughly drench with water for 15-20 minutes.
-Must hold eyes open - someone may have to assist.
-Get medical treatment immediately.

6. Chemical Ingestion

Treatment

-Dial 911 to report the emergency, then Contact Poison Control Center: 8-1-800-562-9781 for first aid instructions.
-If needed: Syrup of Ipecac, granulated charcoal, and Epsom salts are available in the First Aid Kit , administered only under the direction of the Poison Control Center.
-Get medical attention immediately.

7. Chemical Inhalation

Symptoms

-Excessive flow of tears.
-Choking and coughing.
-Chest pain.
-Nausea and vomiting.
-Person may have collapsed.

Treatment

-Move from area immediately to fresh air if possible. DO NOT ENTER room if low oxygen alarm is activated.
-Absolute rest, do not allow victim to move about.
-Apply artificial respiration if necessary.
-Get medical attention immediately.

8. Cuts

Treatment

-Put on Latex Gloves before treating.
-Thoroughly clean the wound.
-Cover it with a single layer of non-sticking gauze.
-If non-sticking gauze is not available, cover with a good antiseptic first aid cream then dress the wound.
-Bandage with sterile gauze pad and adhesive tape.
-Necessary items are in the First Aid Kit.
-Use first aid procedures to stop excessive bleeding.
-Get medical treatment if necessary.

9. Lacerated Wounds

Treatment

-Put on Latex Gloves before treating.
-Cover the injured area with a thick sterile dressing.
-Bandage it firmly in place.
-Necessary items are in the First Aid Kit.
-Get medical attention.

10. Electrical Shock

Prevention

-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.

Accidents

-Assume that the power is still on. Locate the main power switch and turn off.

IMPORTANT: DO NOT TOUCH VICTIM OR LIVE WIRES UNTIL IT IS CONFIRMED THAT THE POWER IS OFF. DO THIS BEFORE TOUCHING THE VICTIM.

-If a live wire is trapping the victim, turn off main power switch.
-Once electrical contact has been broken, check if 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 and get permission from Occupational Safety and Health Services Office before turning electricity back on.

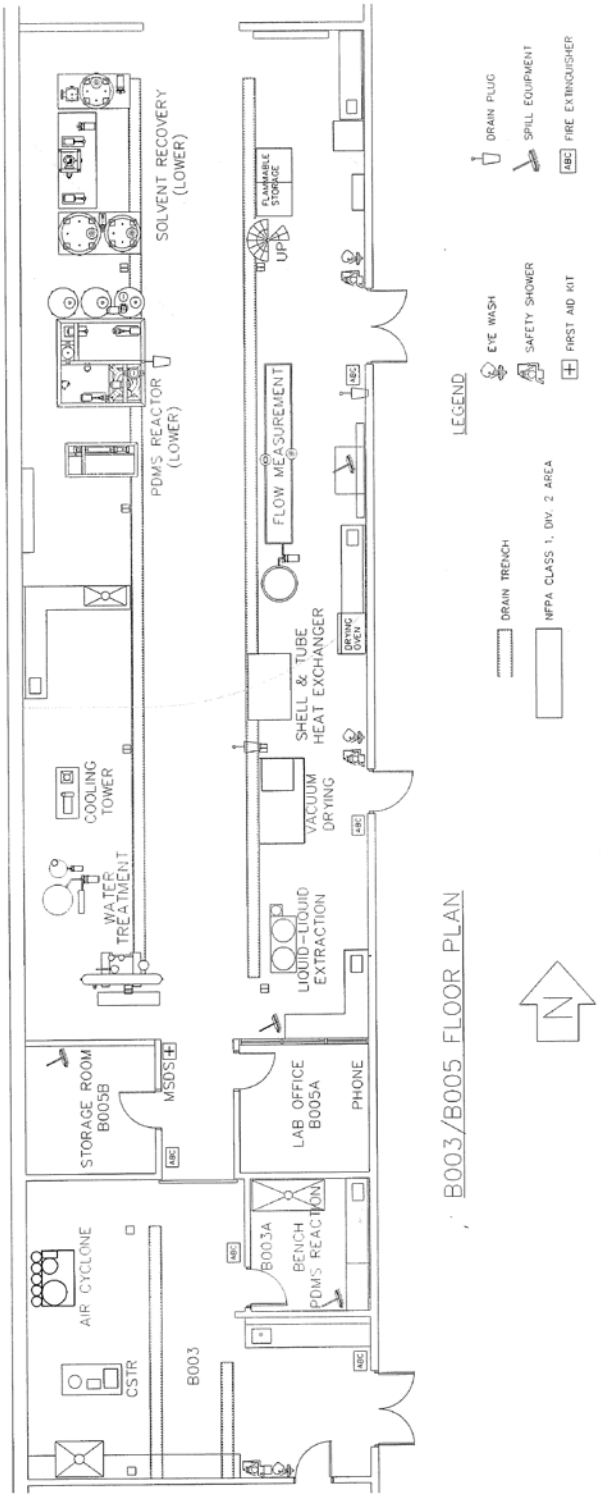
11. Fire

-Use the Safety Shower to extinguish a clothing fire.
-Use fire extinguisher to put out an equipment or facilities fire if this can be done without endangering yourself.
-Shut down experiment.
-Take walkie-talkies with you (PSCC Experiments).
-Evacuate laboratory immediately and safely.
-Sound fire alarm (Located on wall in hallways near building exits).
-Dial 911 on any campus phone.
-Team Leaders verify that all team members were evacuated.
-Team Leaders meet in lobby of ME-EM building to report to the TA or Laboratory Supervisor on status of team members.
-Do not re-enter building until told to do so by a Public Safety Officer.
-Safety Committee should fill out a PAWS Form on the incident.

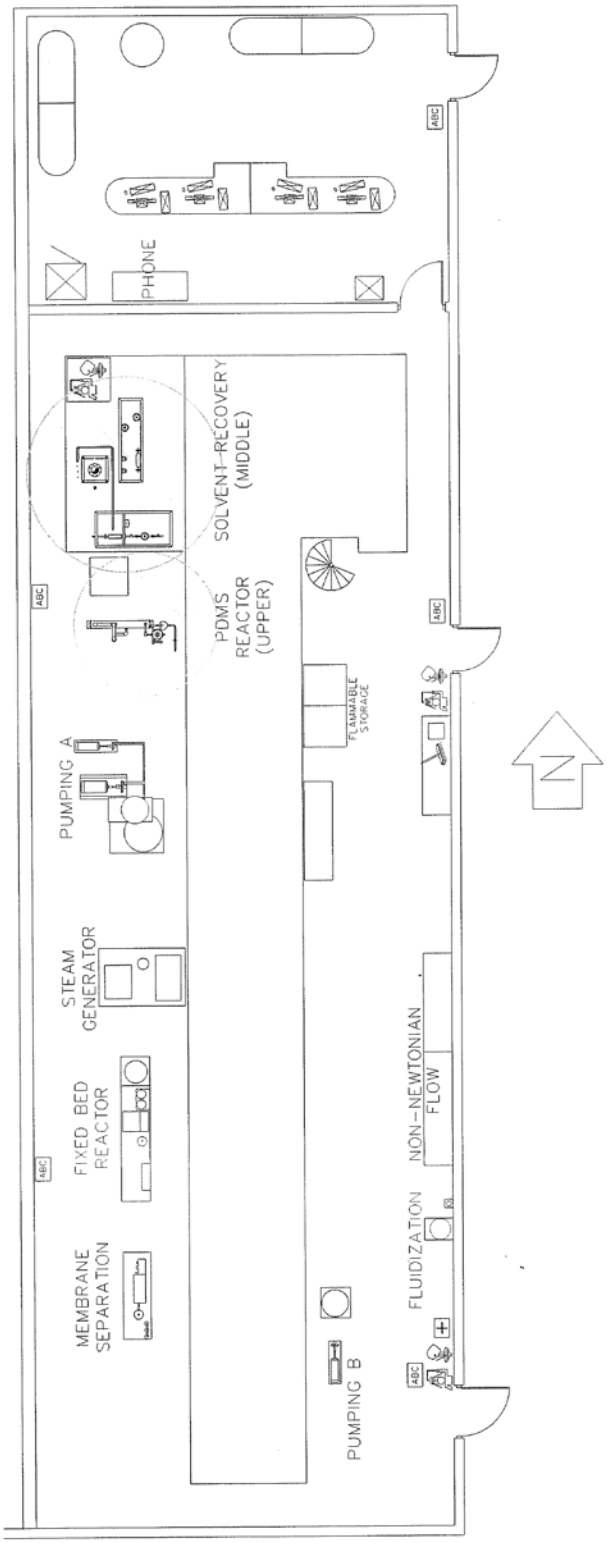
12. Asphyxiation from Low-Oxygen Level

-The low oxygen alarm will automatically go off if oxygen level falls below 19 volume %.
-A continuous bell will sound and a red light will flash.
-The alarm is detectable throughout the laboratory.
-Initiate emergency shut-down procedures and evacuate the lab if the alarm goes off.
-Do not enter the laboratory while the alarm is active.
-Do not allow anyone to enter the lab without SCBA and/or OXYGEN MONITOR if the alarm is active.
-Students should meet in hallway near elevators.
-Team Leaders should verify that all team members were evacuated.
-Team Leaders should report to TA or Laboratory Supervisor.
-Do not re-enter the laboratory until told to do so by the Laboratory Supervisor.
-Safety Committee should fill out a PAWS report on the incident.

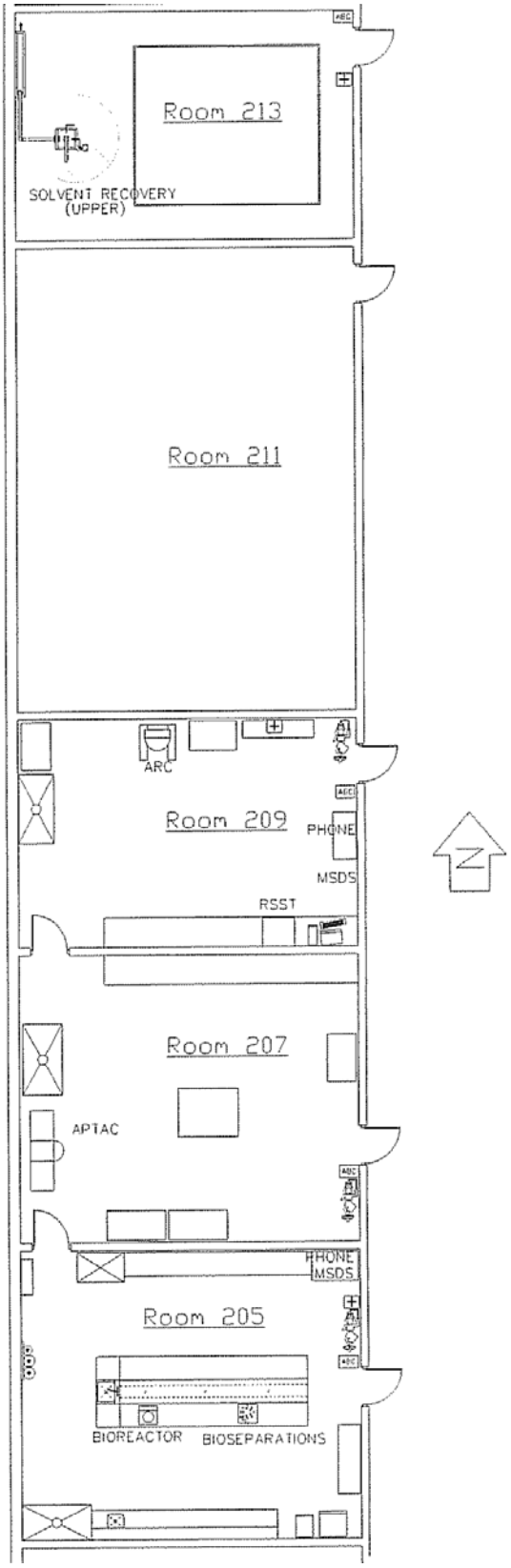
I. Floor Plans and Locations of Safety Equipment



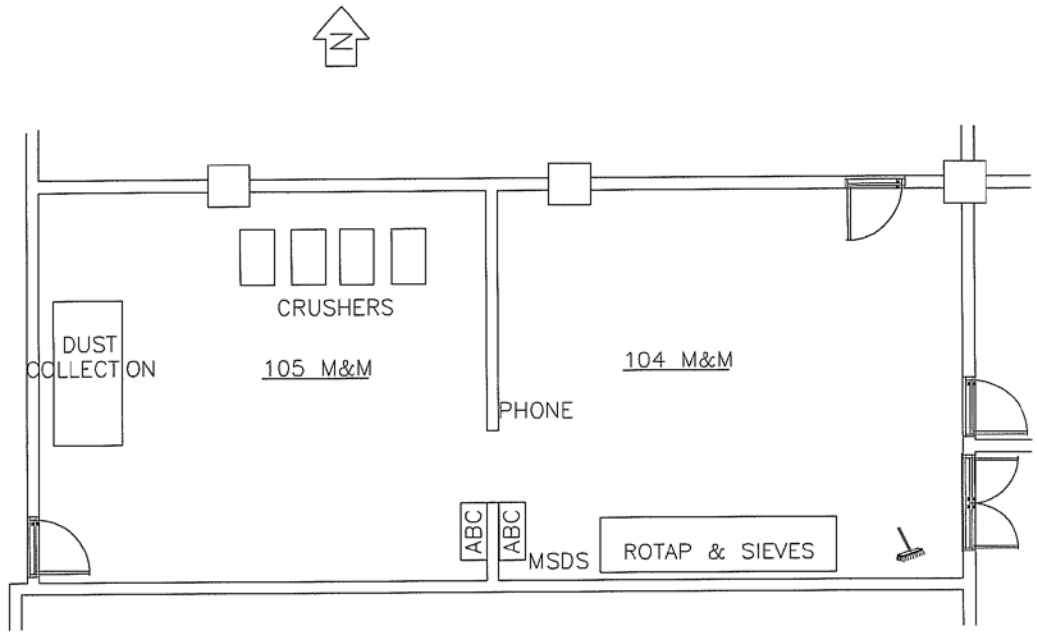
B003/B005 Chem Sci UO Lab Floor Plan



105/107 Chem Sci UO Lab Floor Plan

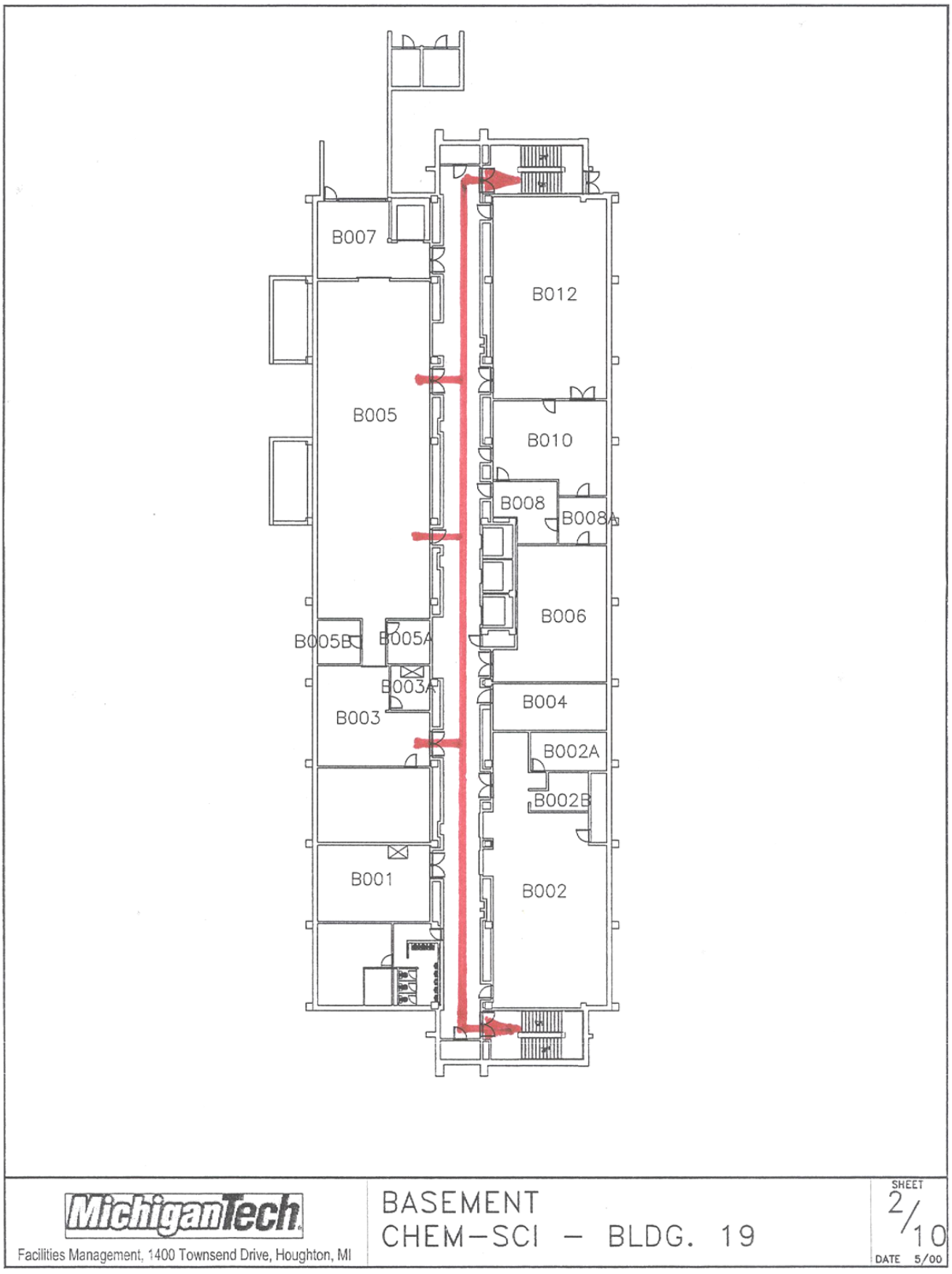


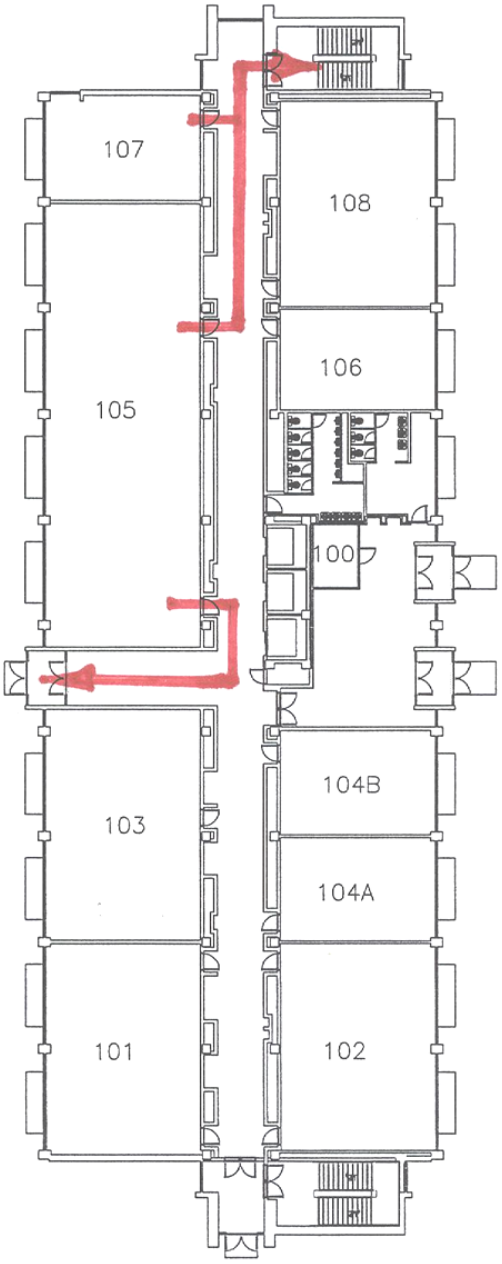
205/207/209/213 Chem Sci Floor Plan



M&M 104/105 Floor Plan

J. EMERGENCY EVACUATION ROUTES



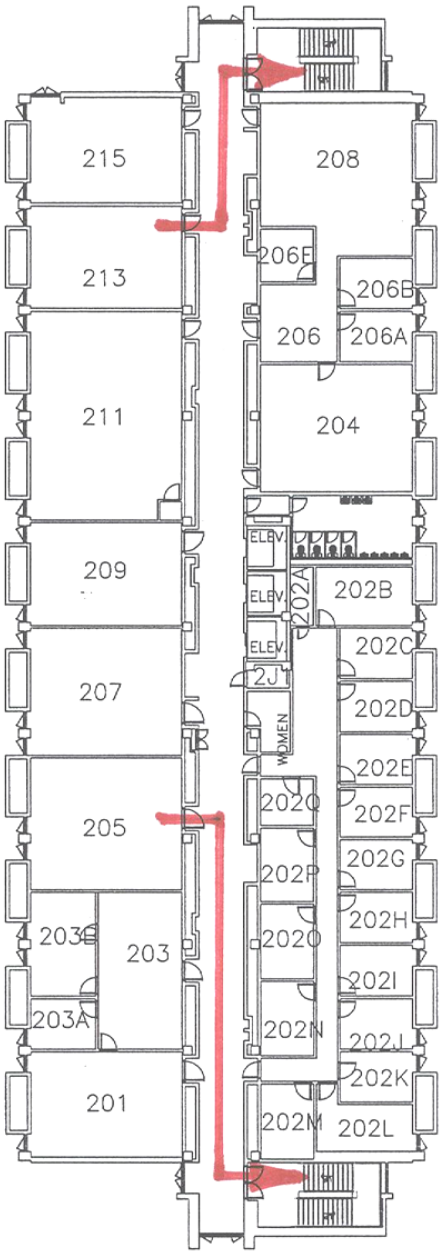


MichiganTech

Facilities Management, 1400 Townsend Drive, Houghton, MI

FIRST FLOOR
CHEM-SCI – BLDG. 19

SHEET 3/10



MichiganTech

Facilities Management, 1400 Townsend Drive, Houghton, MI

SECOND FLOOR
CHEM-SCI - BLDG. 19

SHEET 4/10

K. INDIVIDUAL EXPERIMENTS

The following information is provided to assist in the development of safe operating procedures and hazard identification with each experiment in the Unit Operation Lab areas. Use this information verbatim when writing JSA's.

1. Air Cycloning

Safety

a. Make sure all guards are in place.
b. Check that equipment is properly bonded and grounded.
c. Keep cords away from water.
d. Do not use with combustible dusts.

Additional PPE Required:

Ear plugs required when in the immediate vicinity of the blower
Use dust mask if necessary

Emergency Shutdown Procedures

a. Turn off the main power.
b. Evacuate the laboratory.

2. Advanced Reactive Systems Screening Tool (ARSST)

Safety

a. Know the specific hazards of each chemical used during the experiment, including reactants, intermediates and products.
b. ARSST vessel is under pressure during a test, typically 300 psig.
c. Keep operating pressure below 325 psig to prevent blowing the rupture disk.
d. During cool down, maintain the pressure on the vessel until the temperature is below 100 deg. C to prevent boiling of the sample.
e. Long pants, non-porous safety shoes, and safety glasses are required for all personnel in the laboratory. In addition, for chemical handling, use a face shield with goggles and gloves compatible with the chemicals being used.
f. Use care when handling syringes to prevent skin injection.
g. Be sure hood fan is operating and blast gate is open before starting the experiment.

Additional PPE Required:

Check specific requirements for chemicals used.
Face shield and chemical splash goggles when handling hazardous chemicals.

Emergency Shutdown Procedures

a. Turn off heater switch on the front of the ARSST controller.
b. Evacuate the laboratory.

3. Batch Distillation (TBD)

Safety

a.
b.
c.
d.
e.

Additional PPE Required:

Emergency Shutdown Procedures

a.
b.
c.
d. Evacuate the laboratory.

4. Continuous Stirred Tank Reactors (CSTR)

Safety

a. Keep cart wheels blocked to prevent equipment movement.
b. Make sure all guards are in place.
c. Make sure agitator is immersed in solution before starting and stopping it. Use caution when agitator is running.
d. Be aware of electrical hazards and avoid splashing liquid on electrical devices.
e. Collect any water discharged from the pumps when priming them.
f. Be aware of the possibility of overflowing the tanks. The drain valve on the front of the reactor should be inspected for obstruction before any work begins. Close feed valves immediately and open drain valve if overflow occurs. Notify the Laboratory Supervisor.
g. Clean up spills immediately.
h. Make sure that valves are closed when starting the reaction.
i. Use ethanol to dissolve the phenolphthalein.
j. Sodium hydroxide (NaOH) is a strong base. Use caution when handling it. Ethanol is flammable. Refer to the chemicals section of this manual for information on sodium hydroxide, ethanol, sodium chloride, and phenolphthalein.
k. The workspace for this experiment is limited. Care must be taken to avoid knocking tubes out of the tanks and knocking the tanks over.

Additional PPE Required

Chemical splash goggles and disposable gloves when preparing solutions.

Emergency Shutdown Procedures

a. Close valves on feed lines to the tanks.
b. Turn off the power to the pumps and agitators.
c. Unplug all electrical cords.
d. Evacuate the laboratory.

5. Cooling Tower

Safety

a. Watch for drain backups or pooling of water. This may present a slip hazard. Clean up all spills immediately.
b. Use caution around hot water valves, pipes, and fittings. Use insulated gloves as needed.
c. If you need a ladder to use anemometer, be sure ladder is secure and have a team member brace the ladder. Maintain three points of contact with the ladder when ascending or descending.

Additional PPE Required

Insulated gloves when adjusting tempering valve.

Emergency Shutdown Procedures

a. Turn off main power disconnect behind the cooling tower on the west wall. Be sure to use left-hand rule.
b. Close hot water supply valve.
c. Close cold water supply valve.
d. Evacuate laboratory.

6. Comminution (Size Reduction)

Safety

a. Safety glasses with side shields are required at all times in rooms 104 and 105 M&M.
b. Make sure all guards are in place before starting.
c. Keep fingers and loose clothing away from moving parts of crushers and grinders.
d. Follow Operational Lock-out Procedure in this manual when measuring crusher openings, making adjustments, or performing any other service operations on the crushers.
e. Clean up when you are done.
f. Be aware of electrical hazards and avoid splashing water on electrical devices.
g. Do not operate any equipment in these rooms without the approval.
h. Adjusting the RoTap for the number of sieve trays can expose you to a pinching or crushing hazard. If the RoTap machines have to be adjusted for the number of trays, have one person hold the stack of trays while the other person adjusts the locknut.

Additional PPE Required

Ear protection.
Dust mask.

Emergency Shutdown Procedures

a. Push the red Emergency Stop button on the crusher, or turn off the Rotap sieving machine.
b. Evacuate the laboratory.

7. Fixed Bed Reactor

Safety

a. Make sure all guards are in place.
b. Make sure agitator is immersed in solution before starting and stopping it. Use caution when agitator is running. Replace cover on feed tank after adding feed.
c. Be aware of electrical hazards and avoid splashing liquid on electrical devices.
d. Be sure that product discharge line extends into the cup sink before starting the feed pump.
e. Use only deionized water to make up the feed solution.
f. Clean up spills immediately.
g. Maximum water bath temperature is 65^{o}C.
h. Water bath contains ethylene glycol. Avoid skin contact and ingestion.
i. The catalyst is an irritant. Use rubber gloves and splash goggles when handling.
j. The catalyst should only be changed by a lab supervisor.
k. Use caution when handling glass reactor and polarimeter tube.

Additional PPE Required

Rubber gloves and splash goggles when handling the catalyst or water bath fluids.

Emergency Shutdown Procedures

a. Turn off main power disconnect on west wall.
b. Evacuate the laboratory.

8. Flow Measurement and Control

Safety

a. Clean up any spills immediately.
b. Be careful when using water near electricity.

Additional PPE Required

None.

Emergency Shutdown Procedures

a. Turn off the pump.
b. Close water supply valve.
c. Turn off main power supply.
d. Evacuate the laboratory.

9. Fluidization

Safety

a. Open the valve on the air supply slowly.
b. Manometers are used in this experiment; follow proper manometer operating procedure.
c. Before using the red oil manometer determine if the pressure drop is small enough to be displayed on the red oil manometer.
d. Keep the valves closed to the high and low pressure sides of orifice plate when not taking manometer readings.
e. Clean up any spills immediately.
f. If sand is to be screened, stay clear of Ro-Tap screening apparatus, wear ear plugs when operating, and wear a dust mask.
g. Consult the MSDS for safety information on the material being fluidized.

Additional PPE Required

Ear plugs and dust mask when operating the Ro-Tap machine.

Emergency Shutdown Procedures

a. Close the valve on the air supply.
b. Open manometer by-pass valve if it is closed.
c. Turn off the Ro-Tap if it is being used.
d. Evacuate the laboratory.

10. Liquid-Liquid Extraction

Safety

a. Refer to the chemicals section for the hazards of ethanol, glacial acetic acid, Isopar-M, phenolphthalein, potassium hydrogen phthalate, and sodium hydroxide.
b. Wear protective gloves, apron and a face shield when handling glacial acetic acid. The apron and gloves should be rinsed, dried, and folded neatly after each use.
c. Make sure the main lab vent fans (HF-2 and HF-54) and the local exhaust fan is turned on before opening any glacial acetic acid containers or starting the equipment.
d. Valve LE-V-6, at the top of the product tank, must remain open at all times.
e. For small Isopar-M spills use clay absorbent or paper towels. For large Isopar-M spills use the drain plug to block the drain, use the spill dike to contain the Isopar-M and then use clay to absorb the spill. The contaminated waste material should be placed in the wastebasket and transferred directly to the dumpster outside the building.
f. All samples should be poured into the waste sample jug after analysis. Lab supervisors will properly dispose of the samples at the end of the day.
g. Be sure that the drain valve (LE-V-12) is closed after draining off any water from the tanks.
h. Be sure that all sampling valves are closed after taking samples.
i. Use the five-gallon safety cans for adding Isopar to the system. Clamp a grounding cable to the safety can and to the feed tank before pouring.

Additional PPE Required

Rubber gloves, rubber apron, and face shield for glacial acetic acid.
Disposable gloves for titrating samples.

Emergency Shutdown Procedures

a. Turn off pump switch (East wall).
b. Close valves that control column flow.
c. Close all sampling valves.
d. Evacuate the laboratory.

11. Membrane Separation

Safety

a. Refer to the chemical section for the hazards of oxygen (O_2) and nitrogen (N_2).
b. Proceed with emergency shutdown and then evacuate the area immediately if the low-oxygen alarm sounds.
c. Use “left hand” rule when turning on/off the electrical power on the West wall.
d. Do not close air outlet valve when running the experiment because of pressure hazard.
e. Power switch should not be on at any time when air is not passing through the unit. An interlock should prevent this from happening.

Additional PPE Required

None.

Emergency Shutdown Procedures

a. Pull main power switch on the west wall to the off position.
b. Close on/off valve for air inlet.
c. Evacuate the laboratory.

12. Non-Newtonian Flow

Safety

a. The maximum working pressure for the capillary viscometer is 20 psig. Never exceed 20 psig.
b. The polymer solution should be filtered before it is used in the capillary viscometer.
c. The polymer solution is very slippery. Clean up spills immediately using a solid absorbent.
d. Follow safety procedures for mixers.
e. Refer to the chemicals section for safety information on the polymer.
f. The temperature bath cooling water flow should be set to a minimum to prevent splashing at the sink drain and to prevent waste.

Additional PPE Required

Disposable gloves when handling hazardous chemicals.

Emergency Shutdown Procedures

a. Open manometer by-pass valve.
b. Close valve for main air supply, BPF V-1.
c. Close valve for cooling water supply, BPF V-11.
d. Turn off the heater and pump for the constant temperature bath.
e. Evacuate the laboratory.

13. PDMS Bench-Scale Reactor Experiment

Safety

a. Become familiar with the MSDS's for the chemicals involved – 1.5 cSt Xiameter® PMX-0200, Xiameter® PMX-0245, PDMS fluids, the low boilers, potassium hydroxide (KOH), nitrogen (N_2), carbon dioxide (CO_2) and toluene.
b. Do not load the glass reactor vessel above 50% of rated volume. For a 1-liter reaction flask, the maximum batch size is 500 ml.
c. The endblocker and the low boilers produced are combustible; keep away from ignition sources and store in the Flammable Liquids Storage Cabinet.
d. Silicones can build up static electricity. Minimize free fall of liquids and use proper bonding and grounding when pouring to/from conductive containers.
e. The potassium hydroxide (KOH) catalyst is caustic. Wear rubber gloves, a rubber apron, and safety goggles when handling.
f. Do not transport any chemicals in open containers.
g. The silicone liquids are slippery; wipe up any spills immediately.
h. Keep the system inerted with nitrogen except when using CO_2 to neutralize the KOH catalyst.
i. Nitrogen and carbon dioxide are potential asphyxiants. Make sure that pipe and hose connections are tight and that pipes and hoses are in good condition; report any leaks to the laboratory supervisor immediately.
j. This experiment must be run in a hood. Make sure that the hood is operating correctly throughout the experiment, including start-up and clean-up. The arrows on the hood sash must line up with those on the side of the hood for proper ventilation.
k. Remove all chemicals except PDMS from the hood at the end of the day and return them to their normal storage location.
l. Minimize the amount of toluene used and be careful in handling the toluene to avoid spills.
m. Fully open main gas cylinder valves.
n. Wear gloves when handling hot glassware.
o. Take care when inserting glassware connections into rubber stoppers. Use grease to lubricate connections.
p. Glassware must be transported in a bucket or suitable container.

Additional PPE Required

Rubber gloves, rubber apron, and chemical splash goggles when mixing/ adding KOH solution.
Disposable gloves when using toluene or cleaning glassware with Micro solution.
Insulated gloves when handling hot glassware or when inserting glass tubing into rubber stoppers.

Emergency Shutdown Procedures

a. Turn off and unplug the heating mantle.
b. Leave the nitrogen on.
c. Close the door of the fume hood but leave the hood running.
d. Evacuate the laboratory.

14. PDMS Pilot-Scale Reactor Process

Safety

a. Become familiar with the MSDS's for the chemicals involved – 1.5 cSt Xiameter® PMX-0200, Xiameter® PMX-0245, PDMS fluids, the low boilers, potassium hydroxide (KOH), nitrogen (N_2), carbon dioxide (CO_2) and toluene.
b. The endblocker and the low boilers produced are combustible; store in the flammable liquids storage cabinet.
c. Silicones can build up static electricity. Minimize free fall of liquid and use proper bonding and grounding when pouring to/from conductive containers.
d. Use the designated container to weigh and to transport the endblocker, the 245 Fluid, and the low boilers.
e. The KOH catalyst is caustic. Wear rubber gloves, a rubber apron, and safety goggles when handling.
f. Do not transport any chemicals in open containers.
g. The silicone liquids are slippery; wipe up any spills immediately.
h. Keep the system inerted with nitrogen at all times.
i. Nitrogen is an asphyxiant; report nitrogen leaks to the lab supervisor immediately.
j. If the low-oxygen alarm sounds proceed with emergency shutdown and then evacuate the area immediately.
k. Minimize the amount of toluene used and avoid spills.
l. Wear a face shield when adding chemicals to the reactor.
m. Follow the Standard Operating Procedures. Do not deviate from these unless told to do so by the laboratory supervisor – document any deviations in the run log.
n. Be sure that the pressure at the catalyst adder station (T201) is atmospheric (zero reading on PG242) before opening the valve (RV-5) at the bottom of T201. Add each chemical separately and close RV-5 after each chemical is added. Keep people out of the area below T201 while chemicals are being added.
o. Follow the operating instructions for the HaZcor® sampler. The sample containers will be hot and slippery; wear gloves. Keep a pan under the purge line to prevent spills.
p. Minimize climbing around the skid; avoid contact with hot surfaces, pump shafts, or control valves.
q. Do not exceed the 30 gallon working capacity of the reactor; monitor the reactor level during chemical addition.

Additional PPE Required

Rubber gloves, rubber apron, and chemical splash goggles – when mixing KOH solution.
Rubber gloves, rubber apron, and chemical splash shield when adding KOH solution to the reactor.
Disposable gloves – when using toluene or cleaning glassware with Micro solution.
Insulated gloves – when adjusting steam valves or when removing the Hazcor sample container.

Emergency Shutdown Procedures

a. Shut off electrical power to the skid.
b. Leave nitrogen on.
c. Evacuate lab if necessary.

15. Pumping A

Safety

a. Be sure that pump guards are in place and properly installed.
b. Do not run cords across the walkway.
c. Keep the walkway clear.
d. Be careful not to overflow the weigh tank.
e. Set the packing gland cooling water to a low flow rate. A high cooling water flow on the packing gland will cause water to flow onto the floor and drip to the basement level.

Additional PPE Required

None.

Emergency Shutdown Procedures

a. Turn off pumps (West wall power boxes).
b. Close any drain valves.
c. Turn off main power supply (North wall).
d. Evacuate the laboratory.

16. Pumping B

Safety

a. Do not overfill tanks.
b. Be sure that pump guards are in place.
c. Make sure all power cords are clear of walkways and moving machine parts.
d. Make sure startup and shut down procedure is executed properly so that the capacitors in the full wave rectifier power supply are sufficiently discharged.
e. Be careful not to allow any water near the power sources or connections.

Additional PPE Required

None.

Emergency Shutdown Procedures

a. Turn off field power supply.
b. Turn off armature power supply.
c. Turn off power supply.
d. Make sure that the water supply is shut off.
e. Evacuate the laboratory.

17. Shell & Tube Heat Exchanger

Safety

a. Steam is used, valves and exposed steam lines may be hot. Wear insulated gloves and long sleeves when operating this equipment. Avoid contact with any uninsulated hot surfaces.
b. Open steam valves slowly.
c. Be sure that all hoses extend securely into the drain.
d. Stay clear of the steam trap, especially when steam is first turned on.
e. Occasionally, a floor drain cover will be removed to drain water. Secure the area around the drain.
f. Clean up any water spills immediately.
g. Leave the DC power supply for the instrumentation and controller energized at all times, even after shutdown.

Additional PPE Required

Long sleeved shirt and insulated gloves to protect exposed skin from contact with hot surfaces.

Emergency Shutdown Procedures

a. Close the main steam valve.
b. Close main water valve.
c. Evacuate the laboratory.

18. Solvent Recovery -- Distillation

Safety

a. Become familiar with the MSDS's for denatured ethanol (C_2H_5OH) and nitrogen (N_2).
b. Ethanol is volatile and flammable; keep sample bottles and collection bottles closed.
c. If the distillate is drummed, store in the flammable liquids storage cabinet.
d. To avoid build up of static electricity, use proper bonding and grounding when transferring ethanol to the feed tank or distillate to a drum.
e. Keep the system inerted with nitrogen at all times.
f. Nitrogen is a potential asphyxiate; report any nitrogen leaks to the laboratory supervisor immediately.
g. Proceed with emergency shutdown and then evacuate the area immediately if the low-oxygen alarm sounds.
h. Follow the procedures in the operating manual. Do not deviate from these unless told to do so by the faculty member in charge or by the laboratory supervisor.
i. Loitering or horseplay in the PSCC Control Room (Room 107) is prohibited.
j. The TA's should test each new group on the Emergency Shutdown Procedures before control is transferred to the new group.

Additional PPE Required

Insulated gloves when handling hot sample containers or adjusting steam valves. Disposable gloves when analyzing samples.

Emergency Shutdown Procedures

a. Turn off the feed pump (P-105_Feed), distillate pump (P-108_Distillate), and bottoms pump (P-107_Bottoms).
b. Stop steam flow to the reboiler by setting FIC131 to Manual and setting the output to 0%.
c. Stop steam flow to the reflux heater by setting TIC151 to Manual and setting the output to 0%.
d. Stop steam flow to the feed heater by setting TIC126 to Manual and setting the output to 0%.
e. If the overheads and bottoms are currently being transferred back to the feed tank: Turn off distillate transfer pump (P-109) and bottoms transfer pump (P-106). Note that these pumps are locally operated from the motor control panel on the north wall of the basement level.
f. Evacuate the laboratory.

19. Vacuum Drying

Safety

a. Keep away from hot steam lines.
b. Use insulated gloves at all times for operating steam valves and handling sample trays or other hot objects.
c. If material is to be screened, stay clear of the Ro-Tap screening apparatus and wear ear plugs when operating. Wear a dust mask when screening sand.
d. Turn on condenser water before attempting to dry any material.
e. Consult the MSDS for safety information on the material being dried.

Additional PPE Required

Long sleeved shirts and insulated gloves around the hot oven.
Dust mask and ear plugs if the Ro-Tap machine is used.

Emergency Shutdown Procedures

a. Turn off the steam valves.
b. Close the vacuum valve.
c. Turn off the Ro-Tap if it is being used.
d. Evacuate the laboratory.

20. Water Treatment

Safety

a. Make sure agitator and pump guards are in place and tank covers are installed before starting any rotating equipment.
b. Turn off the agitator when adding salt to the brine tank.
c. Add water to the brine tank before adding salt. Use proper lifting technique when adding salt.
d. Replace the brine tank cover before starting the agitator.
e. Completely rinse and flush all piping, tanks, and pumps with fresh water before shutting down at the end of the day.
f. After flushing all the brine-contaminated water from the system, close block valves V-8 and V-10 around the TRASAR control unit so that the probes are continuously immersed in water after shutdown.
g. After closing block valves V-8 and V-10, shut off all mixers and pumps and drain the rest of the system.

Additional PPE Required:

none

Emergency Shutdown Procedures

a. Turn off pumps.
b. Turn off mixers.
c. Evacuate the laboratory.

L. CHEMICALS USED IN THE UNIT OPERATIONS LABORATORY

Suggested MSDS Websites: http://www.mtu.edu/sds

1. Non-Hazardous Chemicals – These chemicals are considered to be non-hazardous because of their characteristics or because the volumes used are very small. Normal safe handling precautions and good personal hygiene practices should be followed. The general first aid procedures for skin and eye contact, for ingestion, and for inhalation should be applied. (See L. Possible Accidents and J. Safety Equipment). Consult the MSDS for further information.

Chemical	Where Used & Comments
Carbon Dioxide (CO_2)	PDMS Reactor & Bench-Scale Reactor - High pressure gas, asphyxiate
Glycerin	Non-Newtonian Flow - Viscosity Standard
Isopar-M	Liquid-liquid Extraction – Mineral oil, combustible liquid, contains acetic acid
Methocel®	Non-Newtonian Flow - Avoid producing dust
Natrosol®	Non-Newtonian Flow - Avoid producing dust
PDMS (Polydimethylsiloxane)	PDMS Jacketed Reactor & Bench-Scale Reactor - Silicone product, slippery
Phenolphthalein Indicator (Dissolved in Ethanol)	Liquid Extraction & CSTR
Polycarbonate	Fluidization - Plastic particles
Polyethylene	Fluidization - Plastic particles & Polymer Extrusion - Resin
Polyox®	Non-Newtonian Flow - Avoid producing dust
Potassium Hydrogen Phthalate(KHP)	Liquid Extraction – For standardizing NaOH
Red Oil	Fluidization, Fume Hoods - Manometer Fluid
Sand	Fluidization & Vacuum Drying
Sucrose	Fixed Bed Reactor
Sodium Bicarbonate	Neutralizing agent for acid/base spills
Sodium Chloride	Continuous Stirred Tank Reactors, Water Treatment
Talc	Polymer Extrusion – Don't create dust
TRASAR 23299	Water Treatment

2. Hazardous Chemicals

Acetic Acid – Glacial (CH_3COOH)

Hazards
-Primary hazards are skin or eye contact and inhalation (TLV = 10 ppm).
-Strong, corrosive acid.

Where Used: Liquid-Liquid Extraction.

Proper Handling

-Wear appropriate protective gloves, apron, and goggles.
-Use with adequate ventilation.
-Use safety carrier for transportation.
-Store away from bases and oxidizing materials.

First Aid
-Skin Contact
    Flush with large amounts of water.
    Use the Safety Shower.
    Get medical attention immediately.
-Eye Contact
    Flush with large amounts of water.
    Use Eye Wash Fountain.
    Get medical attention immediately.
-Inhalation
    Move victim to fresh air.
    Get immediate medical attention.
-Ingestion
    DO NOT INDUCE VOMITING.
    Contact the Poison Control Center: 8-1-800-562-9781.
    Get medical attention immediately.

Spills
-Neutralize spill with sodium bicarbonate.
-Dilute with water and flush down the drain.

Fires
-Flash point is 40 ^oC.
-Auto ignition temperature is 427^oC.
-Flammable limits are 4.4-16.0 volume-% in air.
-Hazard is moderate when exposed to heat or flame.
-Can react vigorously with oxidizing material.
-Use Class B fire extinguisher.

Acetone ($CH_3C=OCH_3$)

Hazards
-Primary hazards are fire, inhalation (TLV = 750 ppm), and skin or eye contact.
-Avoid prolonged or repeated contact with the skin.

Where Used: Cleaning glassware.

Proper Handling
-Keep away from ignition sources.
-Wear protective goggles and latex gloves.
-Use safety carrier for transportation.
-Keep container closed.
-Use with adequate ventilation.
-Store in Flammable Liquids Storage Cabinet.

First Aid
-Skin Contact
    Flush with water.
    Use Safety Shower if necessary.
-Eye Contact
    Flush thoroughly with water.
    Use Eye Wash Fountain.
-Inhalation
    Move victim to fresh air.
    Get immediate medical attention.
-Ingestion
    Contact Poison Control Center: 8-1-800-562-9781.
    Get immediate medical attention.

Spills
-Eliminate ignition sources.
-Flush down drain with plenty of water.

Fires
-Flash point is -9^{o}C.
-Auto ignition temperature is 490^{o}C.
-Flammable limits are 2.5 - 13 volume-% in air.
-Extremely flammable when exposed to open flames.
-Extinguish fire with Class B fire extinguisher.

Asbestos

Hazards
-An incombustible fibrous chemical used for thermal insulation.
-Inhalation of fibrous dust and its dispersion within the lungs and other parts of the body can cause health problems.

Where Located: Utility piping rack

Health Effects
-Scarring of the lungs.
-Cancer of the bronchial tubes, pleural surface of the lungs, and occasionally other parts of the body.
-These diseases manifest years after first exposure to dust.

Precautions
-Monitor levels of asbestos particles in air.
-If levels are too high (present OSHA PEL, 8 hr. TWA is 0.1 fiber/cc):
1) Asbestos surrounding pipes can be rewrapped.
2) Remove all asbestos and replace with a less toxic material (most likely fiberglass). This must be done by certified people using proper equipment and procedures.
-Do not disturb asbestos insulation, asbestos dust will be produced.

Endblocker – 1.5 CSt Xiameter® PMX-0200

Hazards
-Primary hazards are fire and slipping.
-Can build up static electricity.
-Minimal health hazards (TLV-TWA = 10 ppm).

Where Used: PDMS Jacketed Reactor & Bench-Scale Reactor - Siloxane reactant.

Proper Handling
-Keep away from ignition sources.
-Use proper bonding and grounding when transferring.
-Wear protective goggles.
-Store in Flammable Liquids Storage Cabinet.

First Aid
-Skin Contact
    Wash immediately with water if contacted.
    Use the Safety Shower if necessary.
-Eye Contact
    Flush immediately with large amounts of water.
    Use Eye Wash Fountain.

Spills
-Eliminate ignition sources.
-Clean up immediately to prevent fire and slippery floors.
-Use solid absorbent and place in Flammable Waste Container.

Fires
-Flash point is 57^{o}C for 1.5 CSt PDMS.
-Avoid sparks or open flames.
-Use Class B fire extinguisher.

Ethanol and Denatured Ethanol – (C_2H_5OH)

Hazards
-Primary hazards are fire, ingestion, inhalation (TLV is 1000 ppm), skin or eye contact.
-Denatured Ethanol contains Ethanol, Methanol, Ethyl Acetate, and Aviation Fuel

Where Used:
Liquid-Liquid Extraction (Titrations)
Solvent Recovery – Distillation
Solvent for Phenolphthalein Indicator (CSTR and Liquid-Liquid Extraction)

Proper Handling
-Keep away from ignition sources.
-Wear protective goggles and gloves.
-Use with adequate ventilation.
-Use safety carrier for transportation.
-Use proper bonding and grounding when transferring.
-Store in Flammable Liquids Storage Cabinet.

First Aid
-Skin Contact
Wash immediately with water if contacted.
Use the Safety Shower if necessary.
-Eye Contact
Flush immediately with large amounts of water.
Use Eye Wash Fountain.
-Inhalation
Move victim to fresh air.
Get immediate medical attention.
-Ingestion
Contact Poison Control Center: 8-1-800-562-9781.
Get immediate medical attention.

Spills
-Eliminate ignition sources.
-Flush down drain with plenty of water.

Fires
-Flash point is 12.2^{o}C.
-Auto ignition temperature is 426^{o}C.
-Flammable limits are 3.3 - 19 volume-% in air.
-Avoid sparks or open flames.
-Use Class B fire extinguisher.

Hydrochloric Acid - HCl

Hazards
-Primary hazards are skin or eye contact and inhalation (TLV = 5 ppm).
-Strong, corrosive acid.

Where Used: Used in Summer Youth Program activities

Proper Handling
-Wear appropriate protective gloves, apron, and goggles.
-Use with adequate ventilation.
-Use safety carrier for transportation.
-Store away from bases.
-Avoid contact with metals - hydrogen can be generated.

First Aid
-Skin Contact
    Flush with large amounts of water.
    Use the Safety Shower.
    Get medical attention immediately.
-Eye Contact
    Flush with large amounts of water.
    Use Eye Wash Fountain.
    Get medical attention immediately.
-Inhalation
    Move victim to fresh air.
    Get immediate medical attention.
-Ingestion
    DO NOT INDUCE VOMITING.
    Contact the Poison Control Center: 8-1-800-562-9781.
    Get medical attention immediately.

Spills
-Neutralize spill with sodium bicarbonate.
-Dilute with water and flush down the drain.

Fires
-Noncombustible
-May react with metals to produce hydrogen - a flammable mixture may be formed (Use Class B Fire Extinguisher).

Low-Boilers from PDMS Polymerization Reactions $[(CH_3)_2SiO]_{3-6}$

Hazards
-Primary hazards are fire and slipping.
-Can build up static electricity.
-Minimal health hazards.

Where Used: PDMS Jacketed Reactor & Bench-Scale Reactor - distilled from reactor after polymerization.

Proper Handling
-Keep away from ignition sources.
-Use proper bonding and grounding when transferring.
-Wear protective goggles.
-Store in Flammable Liquids Storage Cabinet.

First Aid
-Skin Contact
Wash immediately with water if contacted.
Use the Safety Shower if necessary.
-Eye Contact
Flush immediately with large amounts of water.
Use Eye Wash Fountain.

Spills
-Eliminate ignition sources.
-Clean up immediately to prevent fire and slippery floors.
-Use solid absorbent and place in Flammable Waste Container.

Fires
-Flash point will vary depending on polymerization conditions (approx. 45-60^{o}C).
-Avoid sparks or open flames.
-Use Class B fire extinguisher.

Mercury (Hg)

Hazards
-Health effects are cumulative.
-Short-term effects of exposure may be headaches, cough, chest tightness, difficult breathing, soreness of mouth, loss of teeth, nausea, diarrhea, and skin irritation.

Where Found: Thermometers for flash point tester, pressure switch on steam generator.

Proper Handling
-Do not heat a thermometer above its maximum temperature. Use dial or electronic thermometers whenever possible.
- -Use caution when transporting mercury-containing apparatus

First Aid
-Skin Contact
Wash with soap and water.
Use the Safety Shower if necessary.
Get medical attention.
-Eye Contact
Wash with large amounts of water.
Use Eye Wash Fountain.
Get medical attention.
-Inhalation
Move victim to fresh air.
Get immediate medical attention.
-Ingestion
Contact Poison Control Center: 8-1-800-562-9781.
Give milk, egg white, or Syrup of Ipecac to induce vomiting.
Get medical attention immediately.

Spills
-Prevent spill from entering drain (use drain plug and spill dike if necessary).
-Most importantly, notify the Laboratory Supervisor.
-Laboratory Supervisor will conduct clean up.
-Notify groups working in the near vicinity.
-Shutdown experiment if necessary.

Nitrogen (N_2)

Hazards
-Primary hazard is asphyxiation due to lack of oxygen.

Where Used: Membrane Separation, PDMS Jacketed Reactor, PDMS Bench-Scale Reactor and Solvent Recovery - Inerting agent.
Nitrogen is supplied to the PSCC pilot plants as a utility in the Unit Operations Laboratory.

Proper Handling
-Monitor Oxygen level.
-Evacuate the laboratory immediately if the low oxygen alarm sounds.
-Check Oxygen level before entering confined spaces with a continuous supply of Nitrogen (light on low oxygen alarm should be flashing).

Warning: DO NOT ENTER A ROOM FILLED WITH NITROGEN EVEN TO RESCUE A COLLAPSED VICTIM: a self-contained breathing apparatus is required.

-Avoid leaks into confined spaces.
-Always vent to the outside.
-Do not breathe nitrogen-enriched air.
-Use only in well-ventilated areas.

First Aid
-Inhalation
Move victim to fresh air.
Apply artificial respiration if necessary.
Get immediate medical attention.

Oxygen (O_2)

Hazards
-Powerful oxidizing agent stored in a compressed gas cylinder.
-Concentrations above 25 volume % greatly enhance the combustion rate of many materials.
-Primary hazard is the increased flammability of any combustible material.
-Secondary hazard is the hazard associated with compressed gas cylinders.

Where Used: Byproduct of Membrane Separation and nitrogen generator.

Proper Handling
-Keep away from combustible materials and ignition sources.
-Store away from flammable materials.
-Use a pressure regulator designed for oxygen service.
-Keep grease, oil, and other combustibles from coming in contact with oxygen pressure regulators, valves, and fittings.
-Follow proper procedures for compressed gas cylinders.

Leaks
-Entry into an area with a high oxygen concentration can saturate the clothing and increase its flammability.
-Ventilate the area.
-Eliminate ignition sources.
-Close main cylinder valve.
-Tighten all connections and test for leaks. Repeat as necessary.

Fires
-Close main oxygen cylinder valve if possible.
-Use a fire extinguisher appropriate for the burning material.

Potassium Hydroxide (KOH)

Hazards
-Strong alkali.
-Destructive to skin and eyes upon contact.
-Inhalation of dust can damage the respiratory tract.
-Ingestion causes severe injury.
-Can react vigorously with acids and generate much heat.

Where Used: PDMS Jacketed Reactor & Bench-Scale Reactor - Catalyst (used as 45 wt-% water solution).

Proper Handling
-Add to water and not vice versa.
-Store away from acids.
-Carry with a safety container.
-Wear goggles, rubber apron, and rubber gloves.
-Wear full face shield when adding to PDMS Pilot-scale Reactor.

First Aid
-Skin Contact
Flush with water for 15-20 minutes.
Use Safety Shower if necessary.
Get medical attention.
-Eye Contact
Flush with large amounts of water for 15-20 minutes.
Use Eye Wash Fountain.
Get medical attention.
-Ingestion
Contact the Poison Control Center: 8-1-800-562-9781.
Get immediate medical attention.
-Inhalation
Move victim to fresh air.
Get immediate medical attention.

Spills
-Solid
Sweep up spill in manner that will minimize dust formation.
Dilute with water and neutralize with sodium bicarbonate.
Flush down the drain with plenty of water.
-Liquid Solution
Neutralize with sodium bicarbonate.
Flush down the drain with plenty of water.

Sodium Hydroxide (NaOH)

Hazards
-Strong alkali.
-Destructive to skin and eyes upon contact.
-Inhalation of dust can damage the respiratory tract.
-Ingestion causes severe injury.
-Can react vigorously with acids and generate much heat.

Where Used: Liquid-Liquid Extraction – Titrations, Continuous Stirred Tank Reactors.

Proper Handling
-Store away from acids.
-Use spatula when using solid sodium hydroxide.
-Use weighing paper on scale, then discard weighing paper.
-Carry with a safety container.
-Add solid slowly to water.
-Wear goggles, rubber gloves, and rubber apron.

First Aid
-Skin Contact
Flush with water for 15–20 minutes.
Use Safety Shower if necessary.
Get medical attention.
-Eye Contact
Flush with large amounts of water for 15-20 minutes.
Use Eye Wash Fountain.
Get medical attention.
-Ingestion
Give large amounts of water or milk and/or drink vinegar to neutralize the caustic.
DO NOT INDUCE VOMITING.
Contact the Poison Control Center: 8-1-800-562-9781.
Get immediate medical attention.
-Inhalation
Move victim to fresh air.
Get immediate medical attention.

Spills
-Solid
Sweep up spill in manner that will minimize dust formation.
Dilute with water and neutralize with sodium bicarbonate.
Flush down the drain with plenty of water.
-Liquid Solution
Neutralize with sodium bicarbonate.
Flush down the drain with plenty of water.

Sulfuric Acid – H_2SO_4

Hazards
-Primary hazards are skin or eye contact and inhalation (LDL = 135 mg/kg).
-Strong, corrosive acid.

Where Used: Catalyst regeneration for Fixed Bed Reactor, room B003 ChemSci.

Proper Handling
-Wear appropriate protective gloves, apron, and goggles.
-Use with adequate ventilation.
-Use safety carrier for transportation.
-Store away from bases.
-Avoid contact with metals – hydrogen can be generated.

First Aid
-Skin Contact
Flush with large amounts of water.
Use the Safety Shower.
Get medical attention immediately.
-Eye Contact
Flush with large amounts of water
Use Eye Wash Fountain.
Get medical attention immediately.
-Inhalation
Move victim to fresh air.
Get immediate medical attention.
-Ingestion
DO NOT INDUCE VOMITTING.
Contact the Poison Control Center: 8-1-800-562-9781.
Get medical attention immediately.

Spills
-Neutralize spill with sodium bicarbonate.
-Dilute with water and flush down the drain.
-For large spills, set up a dike down hill.

Fires
-Noncombustible
-May react with metals to produce H_2 – a flammable mixture may be formed (Use Class B Fire Extinguisher).

Toluene ($C_6H_5CH_3$)

Hazards
-Primary hazards are fire, inhalation (TWA is 100 ppm), skin or eye contact, and ingestion.

Where Used: PDMS Bench-Scale Reactor and Jacketed Reactor (for cleaning viscometers)

Proper Handling
-Keep away from ignition sources.
-Wear protective goggles and gloves.
-Use with adequate ventilation.
-Use safety carrier for transportation.
-Minimize the amount being used.
-Store in hood in Sample Prep Room.

First Aid
-Skin Contact
    Wash immediately with water.
    Use the Safety Shower if necessary.
-Eye Contact
    Flush immediately with large amounts of water.
    Use Eye Wash Fountain.
-Inhalation
    Move victim to fresh air.
    Get immediate medical attention.
-Ingestion
    Contact Poison Control Center: 8-1-800-562-9781.
    Induce vomiting.
    Get immediate medical attention.

Waste Disposal - Place in Flammable Waste Container.

Spills
-Eliminate ignition sources.
-For small spills use inert absorbent to absorb the spill.
-For large spills use drain plug to block the drain, use spill dike to contain the spill and then use inert absorbent to absorb the spill.
-Place contaminated absorbent/spill dike in Flammable Waste Container.

Fires
-Flash point is 4^{o}C.
-Auto ignition temperature is 480^{o}C.
-Flammable limits are 1.2 - 7.1 volume-% in air.
-Avoid sparks or open flames.
-Use Class B fire extinguisher.

Xiameter® PMX-0245

Hazards
-Primary hazards are fire and slipping.
-Can build up static electricity.
-No significant health hazards (TLV-TWA = 10 ppm) when handled properly.

Where Used: PDMS Jacketed Reactor and Bench-Scale Reactor - Cyclic Siloxane reactant.

Proper Handling
-Keep away from ignition sources.
-Use proper bonding and grounding when transferring.
-Wear protective goggles.
-Store in Flammable Liquids Storage Cabinet.

First Aid
-Skin Contact
    Wash immediately with water if contacted.
    Use the Safety Shower if necessary.
-Eye Contact
    Flush immediately with large amounts of water.
    Use Eye Wash Fountain.

Spills
-Eliminate ignition sources.
-Clean up immediately to prevent fire and slippery floors.
-Use solid absorbent and place in Flammable Waste Container.

Fires
-Flash point is 76^{o}C.
-Flammable limits are 0.52 - 7.0 volume-% in air.
-Avoid sparks or open flames.
-Use Class B fire extinguisher.

M. SAFETY REFERENCES

1. Bethea, R.M., *Incorporation of Occupational Safety and Health into Unit Operations Laboratory Courses*, U.S. Dept. of Health and Human Resources, NIOSH Report 88-79895 (1991).

2. Bretherick, L., *Handbook of Reactive Chemical Hazards*, 3rd Ed., Butterworths, London (1985).

3. Centers for Disease Control, *Biosafety in Microbiological and Biomedical Laboratories*, 3rd Ed., U.S. Government Printing Office, Washington, DC (1993).

4. Crowl, D.A. and Louvar, J.F., *Chemical Process Safety: Fundamentals with Applications*, Prentice Hall, Englewood Cliffs, NJ (1990).

5. Dux, J.P. and Stalzer, R.F., *Managing Safety in the Chemical Laboratory*, Van Nostrand, New York (1988).

6. National Research Council, *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, National Academy Press, Washington, DC (1981).

7. Occupational Safety and Health Administration, *Code of Federal Regulations, 29 CFR 1910*, U.S. Government Printing Office, Washington, DC.

8. Sax, N.I., *Dangerous Properties of Industrial Materials*, 6th Ed., Van Nostrand, New York (1984).

9. Stricoff, R.S. and Walters, D.B., *Laboratory Health and Safety Handbook*, Wiley-Interscience, New York (1990).