



**Montana  
Microfabrication Facility**



**MONTANA**  
STATE UNIVERSITY

**NORM ASBJORNSON**  
College of  
**ENGINEERING**

# Table of Contents

---

## **INTRODUCTION 4**

## **GENERAL INFORMATION 4**

WEBSITE 4  
BECOMING A USER 4  
CONSULTING AND FOUNDRY SERVICES 5  
USER MEETINGS 5  
INTELLECTUAL PROPERTY AND SECURITY 5  
REPORTS AND ACKNOWLEDGEMENTS 6  
FACILITY LOCATIONS AND EQUIPMENT 6

## **POLICIES AND PROCEDURES 6**

PRIORITIES 6  
CODE OF CONDUCT 6  
LABORATORY ITEM AND ACTIVITY RESTRICTIONS 7  
VISITORS 7  
DRESS CODE 7  
    Safety Glasses 8  
    Contact Lenses 8  
    Shared User Management System (SUMS) 8  
EQUIPMENT POLICIES 8  
    Emergency Manual Off (EMO) Buttons 8

## **CLEANROOM POLICIES AND PROCEDURES 9**

PERSONAL EFFECTS STORAGE 9  
SMOKING 9  
GOWNING PROCEDURES FOR BARNARD 107 9  
GOWNING PROCEDURES FOR COBLEIGH LABS 9  
CLEANROOM PROTOCOL 10

## **WORKING WITH CHEMICALS 10**

MONTANA STATE UNIVERSITY LABORATORY SAFETY MANUAL 10  
UNDERSTANDING HAZARDS 11  
SAFETY RULES 11  
BUDDY SYSTEM 11  
CHEMICAL CLASSES AND STORAGE 12  
NEW MATERIALS REQUESTS 12  
WET BENCHES 12  
PERSONAL PROTECTIVE EQUIPMENT 12  
    Donning PPE 12  
    Wearing PPE 13  
    Doffing PPE 13  
LABELING 13  
POURING CHEMICALS 13  
DISPOSING CHEMICALS 13  
CHEMICAL BOTTLE CLEAN-UP 14  
    Solvent Bottles 14  
    Acid, Base, Oxidizer Bottles 14  
HOTPLATE SAFETY 14  
LEAVING WORKSPACES 14

## **EMERGENCY PROCEDURES 15**

EMERGENCY COMMUNICATIONS 15  
EVACUATIONS 15



People with Disabilities	16
CHEMICAL EMERGENCIES	16
Spill Response	16
CHEMICAL EXPOSURES	16
Hydrofluoric Acid Exposure	17
Skin Contact	17
Eye Contact	18
Inhalation	18
FIRES	18

**ACKNOWLEDGEMENTS 19**

**REVISION HISTORY 19**



# Introduction

---

The Montana Microfabrication Facility (MMF) is an open-access micro and nanofabrication facility located at Montana State University (MSU) in Bozeman. The MMF, the Center for Biofilm Engineering (CBE), the Imaging and Chemical Analysis Laboratory (ICAL), and the Proteomics, Metabolomics and Mass Spectroscopy Facility (Mass Spec Lab), make up the Montana Nanotechnology Facility (MONT), a National Nanotechnology Coordinated Infrastructure (NNCI) site.

The MMF offers a range of processing and packaging capabilities, including photo and electron-beam lithography, wet and dry etching, sputter deposition, thermal and electron beam evaporation, chemical vapor deposition, metrology, and inspection. University researchers and industry clients are active in a variety of applications and research areas, including:

1. Optics and Silicon Photonics
2. Micro- and Nano-ElectroMechanical Systems (MEMS/NEMS)
3. Microfluidics and Sensors
4. Physics, Chemistry, and Materials
5. Mono and Bilayer Semiconductor Devices
6. Advanced Packaging
7. Geology and Earth Sciences
8. Life Sciences, Medicine, Microfluidics, and Biosensors
9. Education and Outreach

## General Information

---

### Website

Up-to-date information, contacts, documents, and information about the MMF can be found at our website, <http://www.mmf.montana.edu/>.

### Becoming a User

1. Schedule a meeting to discuss your project by emailing [mmfstaff@sympa.montana.edu](mailto:mmfstaff@sympa.montana.edu). If you are not affiliated with MSU and do not have an MSU NetID, let us know so we can start the process of obtaining one for you.
2. Register using the forms found here: <http://www.nano.montana.edu/projectanduserforms.html>
  - a) PIs must first register each project [https://nano.montana.edu/become-user/PI\\_registration.html](https://nano.montana.edu/become-user/PI_registration.html) **Note that a new form must be submitted for each new project.**
  - b) Each user must then register ([https://nano.montana.edu/become-user/user\\_registration.html](https://nano.montana.edu/become-user/user_registration.html)). These registration forms are used for billing purposes and to collect project and optional demographic information for required reporting to the National Science Foundation.
  - c) Basic Safety Training: go to <https://www.montana.edu/srm/training/vectorsolutions.html> and log in with your netID and password, then follow the instructions for online safety training. Use the list below as a guide for required safety training courses. You can search for these courses in the “extra training tab”. Afterward, save .pdfs of your certifications of completion and email copies to [andrew.lingley@montana.edu](mailto:andrew.lingley@montana.edu). Note that the names listed below are the exact course titles.



- Hazard Communications: Right to Understand (GHS) (28 min)
  - Personal Protective Equipment (PPE) (17 min)
  - Compressed Gas Safety (15 min)
  - Fire Extinguisher Safety (14 min)
  - Electrical Safety (27 min)
  - Ladder Safety (23 min)
  - Science Lab Safety (30 min)
  - Lockout/Tagout: Energy Release (15 min)
  - Chemical Spills Overview (24 min)
3. Finish reading this document, the MMF User Manual (30 min).
  4. Read the MMF Chemical Hygiene Plan (30 min).
  5. Email [andrew.lingley@montana.edu](mailto:andrew.lingley@montana.edu) to schedule a lab tour, onsite safety training, and general wet chemistry training (2.5 hrs).
  6. Take the MMF Safety and Policy Quiz (5 minutes): [link to quiz](#).
  10. Upon completion of the steps listed above, MMF staff will provide you with access to the MMF Reservation System, access codes to the staff office Barnard 111 and other laboratories and will add you to the MMF lab users listserv ([mmfusers@sympa.montana.edu](mailto:mmfusers@sympa.montana.edu)).

## Design Reviews

After an initial feasibility discussion (step 1 in Becoming a User), we strongly suggest meeting with us for a thorough design review. We will talk through various process options and make design recommendations. We will also review your layout and make suggestions to help you get results quickly and painlessly.

## Consulting and Foundry Services

Staff engineers are readily available for design reviews and process troubleshooting at no cost. These consulting sessions are for discussing project concepts, process flows, or specific technical issues. Current or potential users are encouraged to hold discussions with staff on a regular basis to work through processes and to troubleshoot problems. Design reviews can be scheduled as needed by contacting the lab manager or engineering staff.

MMF staff engineers are also available to conduct limited-scope foundry work on a best effort, time-and-materials basis for remote users. Due to the experimental nature of most microfabrication projects, we cannot provide product guarantees but will work closely with you to determine project feasibility, to provide cost estimates, and to obtain mutually satisfactory results.

## User Meetings

User meetings are held the first Tuesday of every month at 3:30 pm in Cobleigh Hall Room 608. First, the staff will discuss current MMF priorities and issues and will make announcements about upcoming impacts to the lab. Afterward, lab users will have an opportunity to discuss any issues.

## Intellectual Property and Security

While working in the MMF, you will not have intellectual property (IP) restrictions or entanglement with Montana State University. Many clients execute an NDA to protect their IP (use of the MSU pre-approved form will expedite the NDA process).



Occasionally staff will engage in collaborative development campaigns with users. In these cases, general processing techniques that are not IP-specific may be shared with the general user base, but applications and full process flows will not be shared unless given explicit permission.

## Reports and Acknowledgements

As a provision of the National Nanotechnology Coordinated Infrastructure (NNCI) program, we are required to submit an annual report on active projects. Occasionally, MMF staff may request input in compiling publication lists and highlighting research in our labs. Additionally, you are required to acknowledge work conducted at the MMF in your posters, publications and presentations. This acknowledgement must include the grant number below. The suggested acknowledgment is: “This work was performed in part at the Montana Nanotechnology Facility, an NNCI member supported by NSF Grant ECCS-2025391.” Your cooperation in response to these requests is mandated by federal funding sources and is greatly appreciated.

## Facility Locations and Equipment

The MMF is spread across several buildings and rooms:

- Cobleigh 523: deposition, furnaces, and wet chemistry
- Cobleigh 525: microfluidics and soft lithography
- Cobleigh 501: back-end, packaging, and test
- Cobleigh 421: dicing saw and general MMF storage
- Barnard 107: lithography, wet chemistry, etching

A complete and updated equipment list can be found on our website:

<https://mmf.montana.edu/about/equipment/>

## Policies and Procedures

---

### Priorities

1. **Safety.** You are responsible for your safety and for those around you. Do not work in the facility when you are tired, sick, medicated, or intoxicated. Read and understand the safety information in this manual, in equipment protocols, and in safety data sheets.
2. **Facility and Equipment Integrity.** Never compromise the equipment or facilities for your research. Understand and abide by equipment restrictions. If you damage or contaminate equipment while straying from equipment protocols, you could be liable for property and equipment damages that may include staff time, spare parts, vendor services, or equipment replacement.
3. **Your Research.**

### Code of Conduct

Assume responsibility for the lab. Follow safety, equipment, and cleanliness protocols, even if your work is not sensitive to contamination or particulates. Never leave a mess; if you find one, either clean it, ask the responsible parties to clean it, or notify staff. Report equipment problems and notify staff and other users if you have made a mistake or may have caused contamination. Share



space and respect equipment reservations. Ask questions. The lab operates effectively when everyone is cordial, follows instructions, and communicates.

### Laboratory Item and Activity Restrictions

The following table lists items and activities that are restricted in all laboratory spaces, cleanroom and non-cleanroom. This is not an exhaustive list; be sure to ask if you have questions.

Partial List of Prohibited Items/Activities	Allowed Items/Activities
Food or drink, gum, cough drops, mints, etc.	Cell phones, headsets
Smoking	Cameras (no flash in yellow rooms)
Offensive or obscene materials or media	Laptops, PDAs, e-readers, music players
Cardboard, fiberboard, wooden containers	Plastic items, plastic boxes, plastic containers
Paper, paper notebooks, books, magazines, etc.	Cleanroom paper, cleanroom notebooks
Pencils, erasers	Pens
Over-the-ear headphones	Ear bud headphones (keep at low volume)
Hats, coats, scarves, bags, backpacks, etc.	Laptops, e-readers, cell phones
Makeup, cosmetics	Dad jokes
Running jogging	Sunny dispositions

### Visitors

Visitors are not allowed in lab spaces without approval. If approved, an active MMF user must escort each visitor during his or her entire time in laboratory spaces and is responsible for the visitor's actions and safety. Visitors are to abide by all safety measures expected of laboratory users and are not allowed to operate any laboratory equipment or perform any chemical operations. Visitors are not allowed in the facility after normal hours or as buddies to meet the buddy system requirement.

### Dress code

You and your clothing should be clean (i.e. free of dust or dirt) before entering lab spaces. Avoid clothing that sheds fibers such as wool, fur, fake fur, mohair, etc.

You must wear shoes that completely enclose the heel, toes, and top of your feet. Socks or stockings are required. Sandals, open-weave shoes, or shoes that expose the top of the foot are not allowed. High heels and deep-treaded shoes that hold mud or dirt are also not allowed. Your shoes should be clean and dry before entering the labs to avoid tracking mud, dirt or leaves into the labs.





You must wear long pants that run from your shirt to your ankles. Shorts, short pants, capris, skirts and dresses are not allowed. During warmer weather, you may bring with you a pair of lightweight hospital-scrub style pants to wear over your shorts.

Your shirt must cover your shoulders and reach from the top of your arms to your pants. Tank tops, halter-tops, and spaghetti strap tops are not acceptable.

### **Safety Glasses**

Safety glasses must always be worn in all labs. The MMF provides safety glasses, or you may choose to purchase your own glasses, if they meet ANSI Z87.1-2003 standards. You can remove your safety glasses when using optical microscopes but remember to put them back on when you step away from the microscope. Safety glasses alone are not acceptable for chemical protection when working with concentrated acids, bases, and oxidizers in the wet benches. Please refer to the Personal Protective Equipment (PPE) section for details in chemical protection protocols.

### **Contact Lenses**

Consistent with recent recommendations from the American Chemical Society, contact lenses are allowed in MMF laboratories, if safety glasses are always also worn. In case of an eye exposure emergency, rinse at the emergency eyewash station with contacts in place and remove them while flushing.

### **Shared User Management System (SUMS)**

The MMF is in the process of implementing SUMS, originally built by Georgia Tech, to measure and control the use of user facilities. The key features of SUMS are listed below:

- Instrument Restrictions
- Instrument Scheduling
- Instrument Problem Reporting
- Use Monitoring
- Review and Corrections
- Billing and Reporting

You will be given a short introduction to SUMS in your lab orientation.

### **Equipment Policies**

- You must be trained and officially qualified before using any equipment.
- Do not use equipment for unapproved purposes.
- MMF staff must authorize all new processes.
- You must report equipment problems or damage in SUMS or via an email to staff.
- Do not use equipment that has been enabled by other lab users.
- Disable equipment when you are finished.

### **Emergency Manual Off (EMO) Buttons**

Most tools have EMO buttons that will disable all power to the system and should only be used in emergencies. Using an EMO can be detrimental to equipment, so you should carefully distinguish process instabilities and uncommon runs from emergency situations. If you notice electrical arcing, smell or see smoke, or determine your health is in immediate danger, do not hesitate to use the





EMO switch. Flickering plasma, unusual etch rates, or a system that will not pump to the expected vacuum do not warrant the use of an EMO.

## Cleanroom Policies and Procedures

---

### Personal Effects Storage

While you are working in the labs or cleanroom, store all personal items, such as coats, knapsacks, bicycle helmets, books, etc., in Barnard 111. Do not bring any of these items into the gowning room or cleanroom.

### Smoking

Users who have been smoking or vaping must wait 30 minutes after they have finished and must rinse their mouth with water prior to entering the cleanroom.

### Gowning Procedures for Barnard 107

1. Before entering the cleanroom, make certain you are dressed appropriately.
2. Before stepping into the cleanroom, step on a blue sticky mat, and then put on a pair of blue shoe covers.
3. Put on a bouffant hair net, enclosing as much of your hair as possible. If you have a heavy beard that could shed, put on a beard cover (use judgement).
4. Put on a pair of nitrile cleanroom gloves.
5. Using an IPA/water squirt bottle, moisten a cleanroom wipe and wipe down all the items you bring into the cleanroom.
6. If you do not have a cleanroom suit already on a hanger, select a hood, coverall, and pair of boots in your appropriate size from the shelves.
7. Put on the cleanroom hood with the seams facing inward.
8. Put on the cleanroom coverall suit; do not drag the suit on the floor in the process. Hold the sleeves in your hand while putting your feet into the suit to prevent the sleeves from touching the floor. Then make sure your nitrile gloves are over the suit cuffs.
9. Tuck the bottom of the hood into the suit, zip up your suit, and snap the top snap on your suit. Use the mirror on the wall to verify that the hood is correctly positioned inside the cleanroom suit.
10. Put on your white cleanroom boots, tucking the legs of the suit into the boot. Connect the strap across the top of the foot and tighten it snugly. Snap the top of the boot to the back of the suit leg.
11. Put on a pair of vinyl or nitrile gloves over the top of your nitrile gloves (double glove). If you will be working with solvents, double glove with nitrile instead of vinyl.
12. Once inside the cleanroom, do not open or unzip your cleanroom suit. If you need to access something within your suit (e.g. cell phone), go into a gray area to do so, and remember to wipe it down before reentry.
13. Disinfect and put on safety glasses.

### Gowning Procedures for Cobleigh Labs

1. Before entering the cleanroom, make certain you are dressed appropriately.
2. Before stepping into the cleanroom, step on a blue sticky mat, and then put on a pair of blue shoe covers.
3. Upon entering the gowning room, put on a pair of nitrile cleanroom gloves.



4. Put on a hair net, enclosing as much of your hair as possible. If you have a heavy beard that could shed, put on a beard cover (use judgement).
5. Using an IPA/water squirt bottle, moisten a cleanroom wipe and wipe down all the items you bring into the cleanroom.
6. If you do not have a cleanroom coat already on a hanger, select a cleanroom coat in your appropriate size from the shelves.
7. Put on cleanroom coat, and then make sure your nitrile gloves are over the suit cuffs.
8. Disinfect and put on safety glasses.
9. Put on a pair of vinyl or nitrile gloves over the top of your nitrile gloves (double glove). If you will be working with solvents, double glove with nitrile instead of vinyl.
10. Once inside the cleanroom, do not open or unzip your cleanroom suit. If you need to access something within your suit (e.g. cell phone), go into a gray area to do so, and remember to wipe it down before reentry.

### Cleanroom Protocol

- If your gloves are torn, soiled, or otherwise contaminated, immediately remove them and put on new gloves.
- Never touch doorknobs, telephones, equipment controls, microscopes or other common objects with chemical gloves, contaminated nitrile gloves, or your bare hands. Cross contamination can permanently damage equipment and expose others to chemical hazards.
- Tacky mats are placed throughout the lab to reduce airborne particulates. Step with both feet onto the tacky mats when passing over them.
- Do not sit or lean on equipment or tables.
- Use all materials (e.g. wipes and chemicals) sparingly to keep costs down.
- Do not leave items strewn about the lab. Hold yourself and others to high standards.

## Working with Chemicals

---

### Montana State University Laboratory Safety Manual

We must follow MSU's Safety and Risk Management (SRM) rules. Complete information, including General Chemical Safety, Laboratory Chemical Safety, and Chemical and Hazardous Waste, can be found on the SRM website:

<https://www.montana.edu/srm/chemicalsafety/>

As a user of the MMF, you must familiarize yourself with this information. You are responsible for understanding and abiding by SRM rules. Take the required safety courses outlined in the section on becoming a new user. In addition to this document, you must also read the MMF Chemical Hygiene Plan found on our website [and SRM's Hazardous Waste Management](#) procedures. Finally, never do any work in the lab, on equipment or with chemicals, if you feel unsafe or are not certain that the procedures provide sufficient protection. Stop and work with staff until you feel confident with our safety protocols and your competence. **If you do not feel comfortable dealing with the worst possible scenario, it is not something you should be doing.**



## Understanding Hazards

Do not use or handle any chemical until you read and understand its label and safety datasheet (SDS). Understand the hazards, handling, storage, disposal, and emergency procedures for every chemical you use. SDSs are in Barnard 111 and are accessible online. Do not use any equipment without understanding the hazards it presents. You also need to know evacuation routes and locations of eyewashes, fire extinguishers, and shower stations.

## Safety Rules

- Full PPE is required at the wet bench in Cobleigh 525 and at the two wet benches in the first room of Barnard 107. Full PPE is also required when using concentrated tetramethyl ammonium hydroxide in the developer bench. Full PPE includes an apron, a face shield, safety glasses or splash goggles, and chemical gloves when working inside the sash of a wet bench.
  - All process containers must be labeled prior to filling.
  - Never stack chemical containers.
  - Never set chemical containers higher than the bench working surface or a hot plate surface.
  - Never work in a wet bench requiring PPE without a designated buddy. Refer to the section below on the buddy system.
  - Never place hands or fingers in chemicals.
  - Do not taste, touch, or smell chemicals.
  - Never use chemicals in a bench where they are not authorized.
  - Do not mix, heat, dispose, or otherwise use chemicals in an unauthorized manner.
  - Work with chemicals in an exhausted fume hood or wet bench.
  - Never mix acids and solvents.
  - Never dispose of solvents down water drains or water down solvent drains.
  - Change your gloves if they might be contaminated.
  - Never remove chemicals from the lab without permission.
  - Do not interrupt other users working with chemicals.
11. If you are unsure of handling or safety procedures, ask a staff member.
  12. When pouring, ensure the entire container stays inside of the hood.
  13. Set the chemical bottle on the bench before capping or uncapping it.

## Buddy System

Most chemicals used for cleaning and etching wafers are very dangerous, so it is required that another authorized cleanroom user accompany you while you are pouring, using, or disposing of concentrated acids and bases. During the hours of 9 AM to 4 PM, if you cannot find another buddy, please ask staff for assistance. You may not assume that someone is your buddy if they happen to be in the lab. You must explicitly notify them that you need a buddy (at least an hour in advance), and they must accept that responsibility. Your buddy may not leave until chemical pouring operations are completed and you have cleaned up. If your buddy will be working with you at a wet bench requiring PPE, they must also be donned in PPE. A buddy must be in the lab within easy earshot while you are handling dangerous chemicals. As a buddy, you may not wear earbuds or earphones until chemical operations are completed.



The only chemical operation that can be conducted without a buddy is photoresist development with low concentration TMAH developers, and only in the wet bench in the Barnard 107 lithography room. If you do not have a buddy for photoresist development, use an apron, face shield, and double nitrile gloves to maintain dexterity while handling tweezers.

## Chemical Classes and Storage

Acids are used for etching metal and cleaning wafers, are generally corrosive, and can be toxic or water reactive (e.g. sulfuric acid). Many photoresist developers are dilute bases, and some concentrated bases can be used to etch silicon. Examples of oxidizers in the lab include hydrogen peroxide and nitric acid. Oxidizers can react violently with organic chemicals. Although the term “solvent” refers to any liquid used to dissolve another material, in a cleanroom setting a “solvent” is typically an organic liquid that is flammable or combustible. We use acetone, isopropyl alcohol, methanol, n-methyl pyrrolidone, dimethyl sulfoxide, and a variety of others. Photoresists are usually photoactive polymers suspended in organic solvents such as propylene glycol monomethyl ether acetate (PGMEA) or cyclohexanone.

All chemicals are stored and used only in authorized locations and storage cabinets. There are separate storage locations for acids, bases, oxidizers, and solvents. Work with staff to ensure you understand correct storage and handling procedures and refer to labels on wet benches and storage locations.

## New Materials Requests

Before bringing a new chemical into the cleanroom, you must get **written permission** from the MMF staff. We do not permit long-term storage of any personal chemicals in the facility or wet benches without explicit permission.

## Wet Benches

We have metal and plastic benches. Except with explicit permission, organic solvents are not allowed on the plastic benches because they will dissolve the working surfaces. Acids and bases are not allowed on metal benches. You are responsible for understanding the specific requirements and chemical restrictions for each bench.

## Personal Protective Equipment

In addition to nitrile gloves and safety glasses, you are required to use additional personal protective equipment (PPE) when working at the wet benches in the wet etch area or when using concentrated tetramethyl ammonium hydroxide (TMAH) in the developer bench.

## Donning PPE

PPE consists of three items that should be donned in the following order: a chemical apron, a face shield, and chemical gloves. Check all items for damage before use. Look for cracks or pinholes in gloves, tears or holes in aprons, and scratches or cracks in face shields. If any gear is damaged (e.g. ripped apron or gloves), discard it and use another item. Rinse damaged items with DI water and dry before disposing. Use care when putting on aprons to avoid ripping the seams, and make sure the apron sleeves are fully tucked under the chemical gloves.



## Wearing PPE

Do not touch anything unnecessarily with the chemical gloves and treat them as though they are contaminated. For example, do not touch face shields, sashes, controllers, or any other equipment with the chemical gloves. It is acceptable to leave your chemical gloves on the edge of a wet bench while you work elsewhere. The apron must always fully cover your shoulders (i.e. make sure it is tied around the neck and do not let it slip off while you work). PPE provided by the MMF is only for temporary protection. It will not protect you from a spill, splash, or mist for a prolonged period.

## Doffing PPE

Rinse and dry the chemical gloves, remove them and hang them up. Hang face shields and avoid scratching the plastic. Lastly, remove the apron and be careful to avoid ripping it. If condensation has accumulated in the apron, use a wipe to dry the inside. Do not leave the apron inside out.

## Labeling

**Prior to filling, all chemical containers, including those to contain water, must be properly labeled even if you do not intend to walk away.** Label the container directly with a permanent marker. Always include your name, the chemical name, and the date. If you plan to leave chemicals out after leaving the room, a phone number or email and an expected time of disposal must also be provided. If the chemical is not regularly used in the cleanroom (e.g. it was brought in after approval from the lab staff), list all hazards.

## Pouring Chemicals

Assume that all chemical bottles are contaminated. Use a bottle carrier when transferring four liter or gallon bottles between wet benches or from storage areas that require walking more than a few feet. Check the label before removing a bottle from the storage location and recheck the label immediately before pouring. Make sure the chemical container you intend to use is set flat on the wet bench surface before you pour into it. Do not try to pour small volumes from gallon jugs; instead, transfer chemicals from gallon jugs to graduated cylinders or beakers, and then pour again from this secondary container. Use good judgement and do not overfill containers. Never return poured chemicals to their original container.

**Use containers that are compatible with your chemicals.** For example, some chemicals or solutions, such as piranha (a mixture of sulfuric acid and hydrogen peroxide), cannot be stored in closed containers even for brief periods of time because they outgas and could cause an explosion. Hydrofluoric acid and buffered oxide etch cannot be used with glassware because they will dissolve the container.

## Disposing Chemicals

To dispose of used solvent, empty it into a solvent drain or into an appropriate waste container. A list of solvents allowed into the solvent drain is posted on the hood and on the hazardous waste label on the waste container. Clean the chemical container (beaker, graduated cylinder, etc.) with acetone and then isopropanol (IPA). Finally, rinse the container with DI water and return the container to the drying rack.





In Barnard 107, most acids, bases and oxidizers can be disposed into sinks in the plastic benches that drain to the neutralization system. A list of allowed chemicals is posted on each bench. Run the faucet so the solution will be diluted at least ten to one with DI water while carefully dumping the acid, base or oxidizer into the sink or dump rinser. Avoid splashing. Try to avoid lifting larger chemical containers if possible (i.e. do not lift large beakers high off the wet bench surface). Rinse the container thoroughly with DI water, and return to the drying rack.

**In the Cobleigh cleanrooms, all acids, bases, and oxidizers must be captured as hazardous waste.**

### Chemical Bottle Clean-up

Use chemicals in partially used bottles before opening new bottles (i.e. do not open a new bottle to avoid cleaning up a used one). Properly clean empty chemical bottles before disposal. Always use a black marker to completely black out the original label after disposal.

### Solvent Bottles

After pouring out the last drops of a solvent, leave the **empty** acetone, methanol, isopropanol, or other solvent bottle open in the back of the metal bench to evaporate for at least 24 hrs. After the solvent has evaporated, purge the bottle with nitrogen for at least 30 seconds. Then rinse the bottle three times with water, cap and dry the outside of the bottle, black out the label, and place it in a service area on the table near the north exit. Leave empty photoresist bottles open in the metal bench as well. Staff will dispose of dried photoresist bottles periodically.

### Acid, Base, Oxidizer Bottles

Rinse acid, base, and oxidizer bottles by filling the bottle half full of DI water, emptying the bottle into a water drain in a sink in a wet bench, and repeating at least three times. Let the bottle drip dry, cap the bottle, and dry the exterior. Black out the label, write “Rinsed” on the bottle, and place in the service area.

### Hotplate Safety

Hotplates are used extensively for baking photoresist and occasionally for heating solutions. Move hotplates to the appropriate location for the process you are performing (hotplates are labeled “moveable” or “do not move”). Do not touch hotplate surfaces. Use extreme care when hotplates are used in proximity to flammable solvents or other liquids. Do not spill on hotplates or spray water on hotplates, and do not heat high vapor pressure solvents. For example, do not heat up acetone or isopropanol without prior approval from lab staff and with safety measures in place. It is acceptable to remove hotplates from a wet bench if you need more room or if you feel more comfortable working without one in the hood. If you need to heat an organic solvent or material in a bottle (e.g. SU-8), heat the container in a water bath, not directly on a hotplate.

### Leaving Workspaces

After using a bench or other workspace, clean up all chemicals, chemical containers, wipes, and other materials (samples, tape, markers, notes, personal effects, etc.). Always leave wet bench surfaces clean and dry within comfortable arm's reach, and as organized as possible.



# Emergency Procedures

---

You are encouraged to visit [www.ready.gov](http://www.ready.gov) to get an overview of emergency preparedness. If you find yourself involved in a major emergency, do not be shy or embarrassed about calling for help or pulling the fire alarm. If possible, when emergency personnel arrive, approach them, tell them that you were involved with the incident, and be ready to explain what happened.

## Emergency Communications

Use a cell phone or the campus telephone to report emergencies. Emergency contact information is posted on the entry doors to every MMF lab. To dial campus numbers from campus phones, simply dial the last four digits of the number. To dial other numbers from campus phones, dial 8, then 1 and the full number. **9-1-1 can be dialed directly from any phone.**

## Evacuations

The information in this section is copied from:

<http://www.montana.edu/emergency/preparedness/evacuation.html>

Evacuation means to immediately leave a hazard location (i.e., building, area of campus, etc.) due to an immediate health or life-threatening hazard.

Written plans for building evacuation that are compliant with federal Occupational Safety and Health Administration (OSHA) regulations have been developed for all facilities at Montana State University in the event of a fire or other emergency.

These plans are available in the Safety and Risk Management office for each department in academic/administrative buildings. Maps showing a means of egress can be found on the exit doors leading from each residential space and in hallways of other buildings. **You should become familiar with these exit routes for any building you frequent.**

In case of a fire or other emergency that requires all occupants to immediately leave a building or area, **evacuation will be signaled by the internal building alarm or by the direction of emergency personnel.** Please follow the directions below:

- Leave the building or area immediately through the nearest exit. Do not follow regular doffing procedures; instead, leave quickly and take off your suit and boots once you have reached a safe location. Evacuation is REQUIRED when the alarm is sounding, for every individual in the building, whether student, faculty, staff or visitor.
- Do not use elevators during an evacuation.
- Exit in an orderly fashion. Do not run or push. Running can lead to falls and injuries.
- Gather at a designated meeting place or at a safe distance from the building or area, taking care not to block entrances and exits. Emergency personnel will need a clear path into and out of the building or area.
- Stay together. Assess who is present. Staff will gather names of anyone in the labs.
- Report the condition and location of any persons unable to leave the building or area or who need assistance to emergency personnel.





- Wait for the all-clear from emergency personnel before attempting to re-enter the building or area. If a fire or other incident makes a building or area unsafe to enter for a significant period, students, faculty, staff and/or visitors will be directed to a temporary shelter.

### People with Disabilities

During an evacuation, follow the same protocol outlined above. If you need assistance leaving a building or area, notify a co-worker, friend, roommate, etc. that you will wait by the nearest stairwell. Do not use an elevator during an evacuation. Also, call 911 or the MSU Police at 406-994-2121 from your cell phone and let the operator know of your exact location. Stay calm until help arrives.

## Chemical Emergencies

### Spill Response

In order to become an onsite user, you are required to complete several SRM safety courses. This training outlines chemical handling and emergency procedures. If you cause or encounter a chemical spill, respond accordingly based on the following scenarios.

- Risk of fire or spills that could spread out of the room: Pull the nearest fire alarm. This alerts the local fire and police departments that there is an emergency at your location and sounds the alarm in the building for everyone to evacuate. Leave the building, helping others as necessary. Then call 9-1-1 and tell them what happened. Stay on the scene to help personnel respond to the emergency.
- No risk of fire, spill and vapor contained in the room, but someone is injured or exposed: Call 9-1-1 only. If someone has been exposed to a chemical, begin decontamination and/or first aid as soon as possible. Evacuate the room and wait for emergency personnel to arrive.
- Everyone is safe, but there is a large chemical spill: Contact the lab staff or call the SRM Emergency contact, both of which are listed on the entrances to the doors on the lab.

**Only attempt to clean small spills for which your training and experience are appropriate.** If you feel comfortable and are properly trained, there are spill kits in both labs for any chemical spill that is not considered an emergency. Spill carts contain acid and base neutralizers, HF spill kits, caution tape for clearing an area, and personal protective equipment. Personal protective equipment includes nitrile and neoprene gloves, aprons, and face shields. Contact staff for large spills (>100 mL) or spills outside of a wet bench. Do not clean spills that occur outside of the fume hood that may require specialized respiratory protection (e.g. large acid or solvent spills, including any HF spills). **For large spills, evacuate immediately, block access into the lab, and let people know what has happened.**

Regardless of the size of spill, contact the staff and report the spill details and how it was cleaned. After the spill is handled properly and everyone is okay, the events need to be reported and discussed to improve spill prevention and evaluate the response as a laboratory group.

Also, if you are involved in a spill or any other incident (e.g. injury, flood, fire, etc.), you must fill out a Report of Incident Form found here:

<http://www.montana.edu/srm/insurance/incidentreporting.html>

### Chemical Exposures

Working with chemicals is dangerous. Dropping a container or leaving a reaction unattended can have serious consequences when chemicals are involved. Work carefully and deliberately; keep in



**MONTANA**  
STATE UNIVERSITY

**NORM ASBJORNSON**  
College of  
**ENGINEERING**

mind what to do if things go wrong. Read the SDS for all chemicals you plan to use to ensure you are aware of hazards and emergency procedures. Avoid exposures by following the rules below:

- Do not work with chemicals when you are too tired to think clearly.
- Keep your workspaces clean and organized.
- Wear personal protective equipment.

If you are exposed to a chemical (other than hydrofluoric acid, discussed in the next section), do the following:

- Stay calm. Move out of the contaminated area.
- Get the chemical off. Fast dilution is key. If the chemical is on skin or soaking through your clothing, go to the safety shower. Pull the handle on the safety shower, and do not worry about getting the floor wet. Stay in the shower for a minimum of 15 minutes, taking off all clothing necessary to minimize exposure to the chemical. Do not be modest, as your life may depend on removing soiled garments! Get coworkers to help shield you or cover you up. If the chemical is in your eyes, use the eyewash, holding your eyes open in the water for 15 minutes.
- Get a coworker to call 9-1-1 as soon as possible. Have them explain the situation to emergency personnel.
- If possible, obtain an SDS to give to emergency personnel. SDS binders are located in the gowning rooms for Barnard 107 and Cobleigh 523.

You must inform MMF staff if you have had a chemical exposure. If you need a hospital visit, take the safety data sheet (SDS) to the hospital to assist with proper medical care.

### Hydrofluoric Acid Exposure

Hydrofluoric Acid (HF) is among the most dangerous chemicals in the MMF, and the medical treatment for exposure is specialized and differs from that of most other chemicals. HF exposure is very serious, as it can cause severe burns, metabolic imbalances, pulmonary edema, cardiac arrhythmias, and death. As little as 100 mL is potentially lethal if untreated. HF and Buffered Oxide Etch (BOE) will not necessarily cause an immediate burning sensation, so respond quickly if you have had an exposure even if you do not feel any immediate pain. A much more thorough examination of HF and of first aid and medical procedures can be found at this [website](#), where the following treatments were taken from.

### Skin Contact

1. Move victim immediately under safety shower and flush affected area thoroughly with large amounts of running water. Speed and thoroughness in washing off the acid is of primary importance.
2. Begin flushing even before removing clothing. Remove all contaminated clothing while continuing to flush with water under a safety shower.
3. While the victim is being rinsed with water, someone should alert first aid or medical personnel by calling 911 and should arrange for subsequent treatment at Bozeman Health Deaconess Hospital.
4. 5 minutes of water decontamination after the removal of all PPE, clothing, and jewelry should be sufficient. If 2.5% calcium gluconate is not available, water irrigation should continue until it is available or transportation to a medical facility is initiated.



5. Immediately after thorough washing, massage 2.5% calcium gluconate gel into the burn site. Apply gel frequently and massage continuously until pain and/or redness disappear or until more definitive medical care is given. The individual applying the calcium gluconate gel should wear double nitrile gloves to prevent a secondary HF burn.
6. After treatment of burned areas has begun, the victim should be examined to ensure there are no other burn sites which have been overlooked.
7. Arrange to have the victim seen by a physician. During transportation to medical care and while waiting to see a medical provider, it is extremely important to continue massaging in calcium gluconate gel.

### Eye Contact

1. Immediately flush the eyes for at least 15 minutes with large amounts of gently flowing water from the eyewash station. Hold the eyelids open and away from the eye during irrigation to allow thorough flushing of the eyes. If the person is wearing contact lenses, the lenses should be removed, if possible. However, flushing with water should not be interrupted, and the lenses should be removed by a person who is qualified to do so.
2. Take the victim to a doctor, preferably an eye specialist, as soon as possible. Ice water compresses may be applied to the eyes while transporting the victim to the doctor. Rubbing of the eyes is to be avoided.

### Inhalation

1. Immediately move victim to fresh air and get medical attention.
2. Keep victim warm, quiet, and comfortable.
3. 100% oxygen should be administered as soon as possible by a trained individual.
4. The victim should be examined by a physician and held under observation for at least a 24-hour period.

### Fires

In the event of a fire, lab users should activate the nearest pull station and evacuate the building.

- When an alarm sounds on your floor or area, begin immediate evacuation following your floor plan. Close doors behind you.
- If you discover a fire, activate the nearest pull station, close the door and evacuate, and call 9-1-1.
- If the fire alarm does not work, call 9-1-1 and notify occupants verbally of the emergency and the need to evacuate. Evacuation Wardens or another responsible party needs to confirm that all occupants are notified.
- If you are on fire, STOP – DROP – ROLL. If another person is on fire, yell “STOP – DROP – ROLL.”
- Evacuate via the nearest stairwell or grade level exit. Do not block exit doors or wedge them in an open position. The doors must remain closed to keep smoke out and maintain safety for evacuation and fire personnel. Leaving doors open makes the stairwells dangerous and unusable. Persons with physical disabilities should follow the procedures listed above in the Evacuation section.



- Go to your pre-determined Evacuation Assembly Point (EAP). You may have two or more EAP's depending on the size of the building. Immediately report to an Evacuation Warden so that she can accurately track which occupants were able to evacuate. Evacuation Wardens will report to the Evacuation Director.
- If you are trapped by smoke, stay low, cover your mouth with a wet cloth, stay near a window, open it but do not break it, hang something out the window to let fire personnel know you are there and put something in the cracks around the door, phone 9-1-1 if possible.

## Acknowledgements

---

This document was created from the Washington Nanofabrication Facility User Manual, which made extensive use of information from the Cornell Nanofabrication Facility, the Lurie Nanofabrication Facility, the Stanford Nanofabrication Facility, and the Center for Nanoscale Systems at Harvard. The Montana State University Emergency Management and Chemical Safety websites and the University of Washington Environmental Health and Safety website and training documentation were also used extensively, sometimes word for word.

## Revision History

---

2019.1: User Manual adopted and edited from the Washington Nanofabrication Facility User Manual.

2019.2: Included feedback from initial readers and SRM on gowning, labelling, and bottle clean up.

2019.3: Included general safety rule of no open flames in the laboratory. Clarified buddy rule, specifically regarding photoresist development.

2019.4: Added link to MMF Safety and Policy Quiz. Updated Becoming a User section.

2020.2: Clarified training course title information in Becoming a User section.

2020.3: Changed gowning procedures slightly to reflect best practices for COVID. Updated the section on chemical labels.

2020.4: Added section on design reviews.

2022.1: Updated BLR training names.

2022.2: Updated NNCI acknowledgement number.

2022.3: Added wording to Working with Chemicals to make sure users only proceed with processes or equipment if they are certain the procedures are safe.

2022.4: Updated training website link.

2023.1: Updated training website link and classes to reflect new Vector Solutions classes.

