University of Minnesota
Minnesota Nano Center

SAFETY MANUAL

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GENERAL INFORMATION

Introduction

The safety rules and emergency response procedures for use of MNC facilities must be read, understood, and practiced at all times. Use common sense when thinking of safety. Think of how your actions will affect other lab users as well as yourself.

The rules described here have evolved from experience and exist to protect you and your fellow researchers. Failure to follow them will result in expulsion from the lab. If you have any questions, feel free to ask a staff member. Remember, there is no excuse for not following these safety procedures.

In addition to this safety manual, users should also be familiar with the Laboratory Safety Plan for the Minnesota Nano Center. The LSP contains more complete information regarding University of Minnesota safety requirements, and is available on the MNC www site at www.mnc.umn.edu. This safety manual, which forms an appendix in the LSP, contains information and procedures specific to the MNC operations.

The MNC laboratory facilities include the cleanroom (room 190) in the Physics-Nanotechnology building and the cleanroom (1-146 through 1-168) and other laboratories (rooms 1-148, 1-132 and 1-138, also known as Areas 1-3) in Keller Hall. **These facilities are open for qualified and trained lab users on a 24 hours a day, 7 days a week schedule.** MNC staff are only present during normal UM work days, which is generally 8AM to 5PM, Monday through Friday, not including holidays. There are 10 UM designated holidays (New Year's Day, Martin Luther King Day, Memorial Day, 4th of July, Labor Day, Thanksgiving Day and the Friday after Thanksgiving, Christmas, and two other days selected by UM Human Relations department). Access to these facilities is controlled by MNC administrative staff. Some equipment, such as the LPCVD, are for safety reasons limited to operation during the normal MNC staff working hours.

Dress Code

No open shoes, sandals, skirts or shorts are permitted in any MNC cleanroom or laboratory. Fully enclosed leather shoes are best for protection from chemical spills. Long pants are required as well. We discourage the use of contact lenses in the laboratory due to the hazard of trapping dissolved chemicals

in or under your lenses. All laboratory users must have eye protection at all times when in the cleanrooms. This means everyone must either be wearing regular prescription eyeglasses or approved lab safety glasses at all times. If you choose to wear contact lenses, we strongly suggest you to wear "chemical splash goggles" when working with or near hazardous chemicals.

Allowed and Prohibited Items

To maintain a safe working environment, certain items are not allowed in the facility lab spaces. Below is a list of common items that are either allowed or prohibited in the facility. This list does not cover everything, so if a user is not positive an item is allowed, they should check with facility staff before bringing it to the facility. This list only covers the labs areas, and not the offices or computer rooms.

Allowed Items	Prohibited Items
Cleanroom paper and notebooks	Books, newspapers, magazines, etc.
Regular paper notebooks (Keller only)	Food, drink, chewing gum, chewing tobacco
Plastic, metal items (properly cleaned)	Regular paper (Physics-Nano cleanroom)
Cell phones, tablets and laptop computers	Chemicals without prior MNC approval
Ear buds (must be aware of surroundings)	Cardboard boxes

Cleanroom Gowning

The cleanroom garments (hood, suit and boots) are made of a woven polyester fabric that is designed to prevent particulate matter from hair, skin and clothes from getting into the environment. The garments are not designed to provide any protection from liquids, so any chemicals that are spilled on the garment will quickly penetrate to the underlying clothes or skin. When working with hazardous chemicals this is means the garment will not provide protection in case of a spill. The cleanroom gloves normally worn are either a nitrile-based or latex-based glove. These gloves are used to prevent particulates from the hands getting into the cleanroom environment and causing contamination. Do not assume they will protect you from hazardous chemicals and even solvents. **When working with hazardous chemicals use appropriate safety equipment, including chemically resistant gloves**.

Once you put on the cleanroom gloves in the gowning room, do not touch your face or any exposed skin with your gloves. As soon as you touch anything in the cleanroom (touch-activation switches, tables, wet benches, etc.) you need to assume that your gloves are contaminated with chemical residue that could lead to a chemical burn.

Buddy System Rules

When working outside of normal staff hours, a buddy is required whenever hazardous materials are being handled. This specifically applies to work involving the handling of hazardous chemicals at wet benches. Handling means pouring chemicals, either fresh solutions from chemical bottles or used solutions from chemical beakers or baths. If you are going to be pouring chemicals from or into a bottle or beaker, you must have a safety buddy nearby who is aware of your work. If you are not pouring hazardous chemicals, but only using an already existing bath or beaker of chemicals, no buddy is required. Hazardous chemicals include all acids, bases (photoresists and developers not included) and solvents other than acetone, methanol, and isopropyl alcohol. Note that usage of normal lithography chemicals, such as photoresists and developers does not require a buddy.

Emergencies After-Hours

If a serious emergency (for example a fire or an accident requiring first aid) arises on weekends or after hours when staff is not immediately available, call 911 to reach the UM police department. Explain the situation and they will coordinate the appropriate response. For facility related emergencies, call the UM Facilities Management call center at 624-2900.

Safety Awareness

Please report any safety problems you encounter to a staff member or email to mnc@umn.edu. Your input and observations will be appreciated.

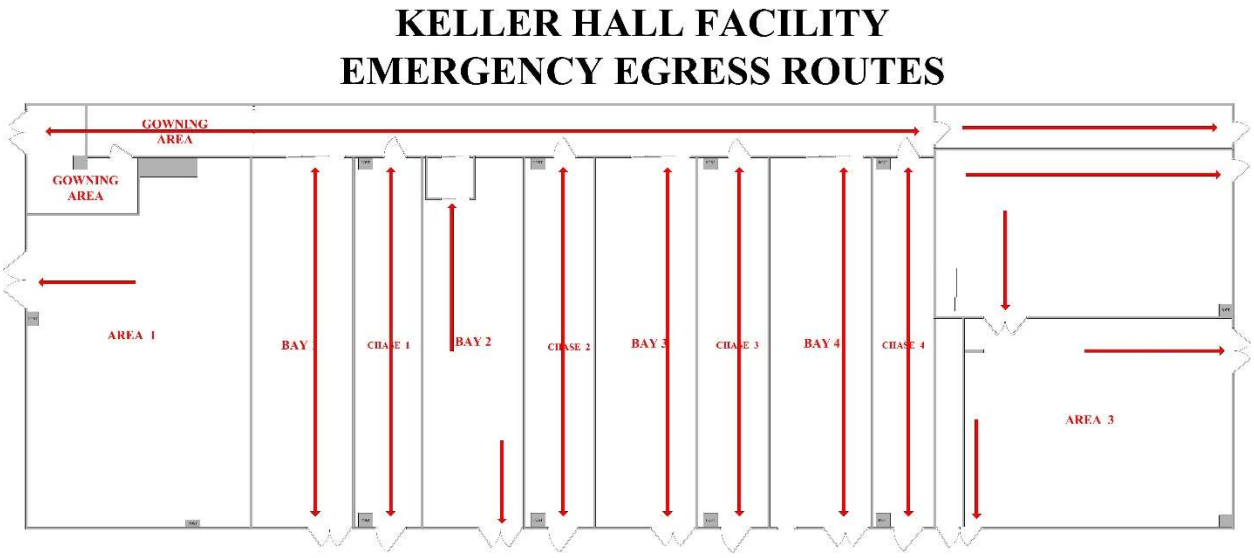
ALARMS AND EVACUATION

As part of the laboratory safety systems, each cleanroom has a toxic gas monitoring system (TGMS) that constantly samples the air in various parts of the lab for hazardous gases, and determines the concentration of any detected gas. If the TGMS determines that a leak has occurred anywhere in the general lab area, and the measured concentration of hazardous gas is above OSHA-defined safety levels, an alarm will sound indicating that everyone should evacuate the lab. **Know the evacuation routes from all parts of the laboratory.** Exit immediately upon hearing the alarm, don't wait to make that last notebook entry. If you are in the middle of a task, finish the task as quickly as possible and exit. For example, if you mixing up a chemical solution, finish pouring the chemical, then cap the bottle and leave the cleanroom. Do not run.

Keller Hall Cleanroom

Fire alarm enunciator with strobe and horn

In Keller Hall the fire alarm is the general alarm signaling that everyone should evacuate. If you are working in Keller MNC facilities and the fire alarm sounds, the cause could be a detected hazardous gas leak that is immediately dangerous to you. Or the fire alarm could be due to a fire in the cleanroom or in another part of the building. There is no way for you to know exactly why the fire alarm is sounding. Regardless of the cause of the alarm, a lab occupant should be concerned with only one thing--exiting the cleanroom or laboratory calmly in the most direct way. Do not stop at the gowning room to remove your cleanroom suit. Once you exit out of the cleanroom, listen to see if the fire alarm is sounding in the rest of Keller Hall. If not, then the alarm is only in the MNC cleanroom and labs, and you do not need to exit the building. Take off your cleanroom suit and put it near the cleanroom entrance door. If the fire alarm is sounding in all of Keller Hall, then immediately proceed to the nearest stairwell, go up to the 3rd floor and exit the building. Go to the lobby of the Physics-Nano building and remove your cleanroom suit. **The lobby of Physics-Nano is the emergency muster site for Keller emergencies.**



Floorplan of MNC labs in Keller Hall level1 showing emergency egress routes

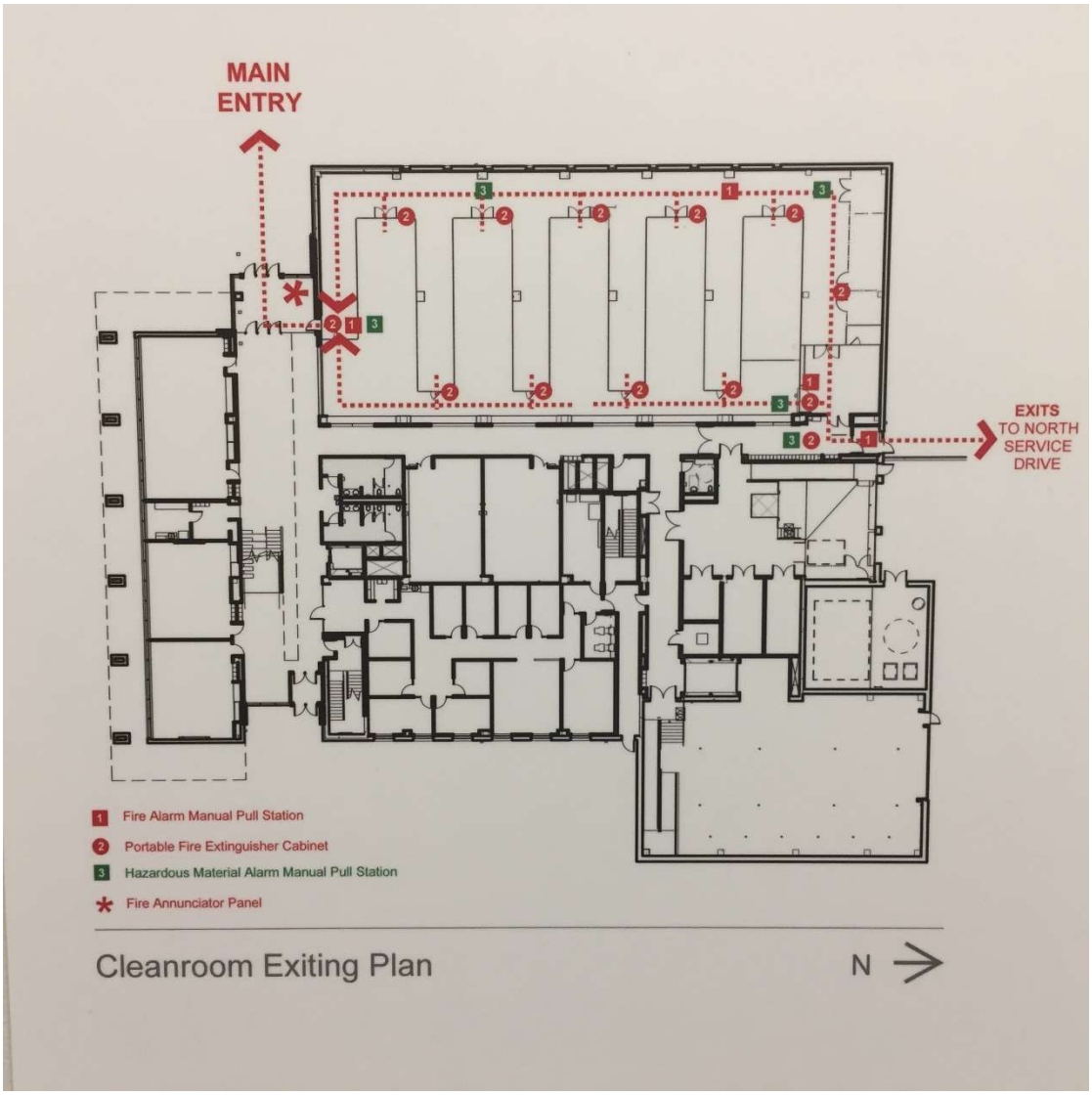
Physics-Nanotechnology Building Cleanroom

The cleanroom in Physics-Nano has dedicated TGMS light/sound towers to indicate status of the system. The light towers are located at many locations around the cleanroom, including just inside and just outside the main cleanroom entrance to the gowning room. There are three lights on the tower:

- Blue light (bottom on tower) means a maintenance issue with the system. System is still operating properly but needs service by MNC staff. No issue for lab users.
- Amber light (second from bottom) means a low level leak has been detected. The measured concentration by the TGMS system is well below the OSHA-defined danger levels for exposure. MNC staff need to address the leak but lab users can continue to work.
- Red light (3rd from bottom) means a dangerous leak has been detected and everyone should evacuate the cleanroom through the main entrance or the through the emergency exit door in chase 6. Each tower also has an emergency horn that will sound when the red light is on. These are very loud horns and will alert you if you do not notice the red light.

Physics-Nano TGMS light tower

If the fire alarm system in Physics-Nano sounds, then you will need to exit the cleanroom and the building as well. If that happens, go to Keller Hall and meet in the main lobby area.



Floorplan for Physics-Nano building floor 1 showing cleanroom emergency egress routing

CHEMICALS

If you are planning on working with chemicals, the wet bench training short courses are mandatory. These short courses inform you of specific procedures, how chemicals are stored and disposed, and what chemicals are used at each wet bench location. Be sure and take the training for the wet benches in the lab you are using.

Chemical Information and Reference Materials

A large variety of chemical safety information is available on-line from the safety data sheets (SDS) prepared by manufacturers. On the MNC www site there is a list of chemicals approved for use in MNC facilities and a copy of the SDS. The MNC Lab Safety Plan is a comprehensive description of the rules and procedures that have been instituted campus-wide for safe chemical usage. This plan is also available on the MNC www site. Consult these sources BEFORE using a chemical with which you are

unfamiliar. Learn about the risks, recommended personal protective equipment (PPE), and proper disposal methods. Handling chemicals requires common sense.

Allowed Chemicals

The chemicals that have been approved for use in MNC cleanrooms is found on the MNC www site. Look through the list of chemical safety data sheets (SDS)—if the chemical you wish to use is there, then you can use it. If the chemical you wish to use does not have a SDS in the list, then it has not been approved. Contact by email the MNC lab manager to request approval. Provide the SDS, and describe the purpose of using the requested chemical, as well the protocol for using, including whether the chemical will be stored at MNC or only used at MNC and stored outside MNC.

Personal Protective Equipment at General Chemical Wet Benches

Before you start working with chemicals at the general chemical benches (this includes all wet benches except those specifically used for lithography chemicals), make sure you are properly protected. Working with hazardous chemicals means you must wear chemically-resistant gloves, a blue chemical splash apron, and safety goggles or a face shield. Always work with chemicals in exhausted wet benches in the laboratory, and if possible keep the chemical beaker or vessel as far back toward the back wall as possible.

Remember that the cleanroom gloves you put on when you enter the lab are to prevent particulate contamination, and are not sufficient to protect against chemical burns. Some solvents can easily permeate through the gloves. Use the orange trionic chemical gloves provided at the wet bench for handling chemicals (put these chemical gloves on over your cleanroom gloves). If gloves, aprons, or face shields aren't readily available near the wet bench, contact MNC staff and the necessary items will be provided to you.

Immersion of your gloved hands in caustic or corrosive liquids is to be avoided if at all possible. If absolutely necessary, then first leak-check the chemical gloves by pressurizing them with a nitrogen gun, then immersing them in water. Check for bubbles, a sure sign of a leak. After using the gloves thoroughly rinse the outside surfaces and discard them if they appear damaged or leak. Otherwise, dry them and store them near the wet bench.

Personal Protective Equipment at Lithography Wet Benches

Lithography chemicals are generally of lower health risk so reduced PPE is allowed. When working at a lithography wet bench nitrile gloves are required, and if the work involves handling (meaning pouring) chemicals, then a face shield should also be worn. Specific situations may arise where full PPE equipment is required, and these situations will be identified and communicated by MNC staff as needed.

Transporting and Handling Chemicals

No chemical bottles are to be transported through the lab by hand. All chemicals are to be moved using individual polypropylene bottle carriers. Bottle carriers are available near the chemical storage cabinets. Please return these carriers when you have finished with them. Please be sure to check that there are no bottles of the chemical you need in your area before bringing in and opening new ones.

When pouring out chemicals for use, never pour chemicals back into the source bottle. This can contaminate the bottle and lead to damage the next user's devices. Always use a funnel when pouring into a small opening, such as when pouring chemical waste into a storage bottle for disposal. Make sure to use two hands to securely hold the bottle, and keep the cap on whenever possible.
When mixing acids with water, remember to **ADD ACID TO WATER** and **NEVER ADD WATER TO ACID.** Use containers (beakers) sized appropriately for the volume of chemicals. Never put HF in a glass container. Always place fuming beakers as far as possible toward the back of wet benches. Clearly label all beakers and glassware containing your chemical mixtures with your name, date and chemicals involved. All chemicals solutions prepared by lab users must be disposed of each day. No beakers of chemical solutions are to left overnight on the wet bench without prior approval from MNC staff. This does not apply to beakers or bathes maintained by MNC staff for general use.

Chemical Spills

Small spills of chemicals (less than 100 milliliters) can be cleaned up by using cleanroom wipes and disposing of the wipes In the event of chemical spills you should be aware of the Chemical Spill Cart located in Chase 1, between Bay 1 and Bay 2. This cart contains several chemical absorbing materials. The Spill pillows are used to absorb and neutralize chemicals. They are contained in absorbent bags and designed so as to minimize interference with our clean rooms. The vermiculite is very absorbent and used on solvent spills to prevent fires. The Spill Pillows should be disposed of by placing in plastic bags (also available in the front of the lab) and contacting a staff member. Personal protective equipment is also stored on the cart for your convenience.

Mixing Chemicals

When mixing acids with water, remember to ***ADD ACID TO WATER*** and ***NEVER WATER TO ACID!***
Use appropriate containers. Never put HF in a glass container. Always place fuming containers down inside the wet benches. Clearly label all beakers and glassware containing your chemical mixtures with your name, date and chemicals involved. Please do not leave chemical processes unattended unless absolutely necessary.

Chemical Burns

If you have a chemical accident resulting in chemicals on your skin or cleanroom suit, immediately remove any contaminated clothing and flush the bare skin with large volumes of water for 15 minutes. Hands and forearms can be rinsed in a wet bench using either the faucet or the DI water spray gun, but for spills on other body areas, use the emergency shower and or eye wash. Remove the contaminated clothing while in the shower. Learn the location of the safety showers and eyewashes in each cleanroom bay, and know how they operate. After flushing for 15 minutes, seek medical attention, as damage may not occur for several hours. If possible, bring a copy of the safety data sheet for the chemical to the medical facility. Contact the MNC office as soon as possible.

Burns from hydrofluoric acid (HF), including mixed solutions like buffered oxide etch (BOE) are particularly hazardous. An insidious aspect of an HF burn is that there may not be any discomfort until hours after exposure. HF easily penetrates through the skin and can attack deep tissues and bones. These burns are extremely serious and result in massive tissue damage. If you contact HF, flush the area well and be sure to scrub under and around your finger nails. This is the classic area where people

receive burns, having washed off the HF and not realizing it went under their nails. HF burns don't produce any burning sensation until after damage has been done. Calcium gluconate cream is an effective treatment for HF burns if applied immediately after exposure. This cream can be found in small tubes near the chemical storage cabinets containing HF solutions. Any HF burns or other serious chemical burns should be looked at by a physician.

Injuries such as minor burns and cuts can be treated with first aid supplies located in the first aid kit mounted in the gowning room.

Emergency Eyewash and Shower Stations

Physics-Nano emergency shower-eyewash station

In the Physics-Nanotechnology building, a flashing strobe light and loud horn are activated whenever an emergency shower or eyewash is activated. The horn stays on as long as the water is flowing. If you witness someone using a chemical shower or eyewash, please assist them as needed and call 911 from a UM phone or cell phone.

To activate the emergency shower, grasp the black handle on the right side and pull down. To shut off the water, push the handle back up. To activate the eyewash, grasp the handle on the left and pull toward your body. The eyewash is located inside the hinged panel that will open, and the water will turn on automatically. To turn off the eyewash simply close the panel by moving it back to the original position.

Keller Hall emergency shower-eyewash station

In Keller Hall the emergency shower is operated by pulling down on the handle hanging beneath the shower head. This opens the shutoff valve that is easily seen on the piping near the showerhead. Water will flow from the showerhead until the handle is used to close the valve by pushing the valve lever up. The eyewash is operated by pushing the green paddle on the right side of the eyewash bowl. As the water comes on the green plastic caps covering the eyewash ports comes off and water streams are available for eye flushing.

Chemical Disposal

When you are through with a chemical process, clean up completely. Dispose of your solutions properly. Waste disposal is an important part of the wet benches short course.

Keller Hall-- there is an acid waste disposal system for the cleanroom. Clear acids, such as hydrofluoric, sulfuric, nitric, and acetic can be disposed of down the drain of wet benches, diluting with a full stream of water from the faucet. Acid mixtures, such as gold and chrome etchants that have other components, should be disposed of in waste containers. There is a list of acids that can be disposed of down the drain at the wet benches in bays 1 and 3. All base waste must go into waste disposal containers. All solvent waste must go into waste disposal containers.

PAN cleanroom-- each wet bench has a different chemical waste disposal process using collection carboys and dedicated drains. In order to learn about waste disposal in PAN, take the appropriate training short course.

Waste disposal containers—these are polyethylene 1 gallon containers used for waste disposal. After finishing with your process, check for a nearby partially filled waste disposal container with the same waste mixture that you can use. If one is not available, obtain an empty container and affix a properly filled out hazardous waste label before storing the container in the appropriate chemical storage cabinet.

COMPRESSED GASES

Handling Gas Cylinders

Cylinders of both toxic and non-toxic compressed gases are used throughout the lab. No one is allowed to install or disconnect these cylinders except MNC staff members. There are several reasons. The gases in these can be at pressures as high as 3000 psi, making a cylinder as powerful as a rocket. Regulators are designed to handle specific gases and can malfunction or even explode if not used properly. Some gases, such as phosphine and arsine, are extremely toxic. Improper installation and purging will contaminate a full bottle of gas. Some of our etching gases cost thousands of dollars and their loss or contamination is very costly.

All gas cylinders must be chained or strapped to a solid object to prevent cylinder damage from falls.

Hazardous Gases

Many hazardous gases such as hydrogen, silane, ammonia, and phosphine are used in the laboratory. These are extremely toxic gases with characteristic odors. Phosphine smells like decaying fish, while ammonia has a pungent, acrid odor. Arsine is also very toxic (the toxic threshold level is 50 parts per billion). Silane, a pyrophoric gas (i.e., it burns upon contact with air) is used at several locations the lab. Hydrogen is used in the lab by the Tylan oxidation furnace bank in bay 1. Its explosive quality is well known. The MNC facilities in both Keller Hall and PAN have toxic gas monitoring systems (TGMS) that are monitoring for hazardous gas leaks on a continuous basis. If a release is detected, the TGMS system determines the concentration level of the hazardous gas. If there is a danger to lab occupants, then the evacuation alarm will sound. If you notice any unusual odors, leave the lab and report it to the staff immediately.

If you notice an unusual odor and suspect a gas leak when staff are not immediately available, such as on a weekend or after hours, leave the lab immediately and take everyone else with you, then call 911.

Nitrogen Guns

Nitrogen guns and compressed air, if not used properly, can inflate the skin like a balloon, tearing it away from the tissue underneath. Be cautious to avoid cuts when spraying nitrogen or working around air streams.

FIRE HAZARDS

Fire Prevention

Fires in the lab can result from the ignition of flammable gases, or solvents, and combustion of materials. A major cause of lab fires is ignition of chemical solutions on hot plates. Always use a water bath to heat flammable organics. **Heating of beakers of solvents on hot plates is not allowed.** Avoid water around electrical appliances.

In Case of Fire

In the event of a fire, pull the nearest fire alarm. Evacuate the laboratory and the building immediately.

ELECTRICAL SAFETY

All electrical wiring is to be done by MNC staff or Facilities Management personnel only. Know the locations of the emergency shutoffs for the equipment you will use. In case of electrocution of someone in the lab, ***DO NOT GRAB THEM***. Call 911. Report all electrical problems to MNC staff.

LAB ETIQUETTE

Mutual consideration of your fellow researchers is essential to the efficient operation of the lab. It will also make life a lot more pleasant for all involved. Please think about how you would like others to deal with you when you are working in a space that is shared by so many.

1. Leave the lab the way you would like to see it when you come in:
    a. No unlabeled containers with chemicals on work areas.
    b. No unlabeled beakers cluttering up the drying area.
    c. No unreported equipment problems.
    d. No used gloves lying around.
    e. A clean photoresist spinner.
    f. No empty bottles lying around.
    g. Work tables clear of debris and clutter.
    h. Toolboxes and other personal supplies put away.
2. Be considerate of your fellow lab users:
    a. Share wet bench space cleanly and safely.

b. If you reserve equipment, show up. If you cannot show up, cancel your reservation.

3. Consider the general welfare of the lab:
    a. Remember, you have a stake in the lab operating smoothly. The lab staff is here to ***HELP***, not to serve you. Lab users are required to clean up after themselves. When you do need staff help, assist them and learn from them.
    b. When you have the slightest doubt about anything, ***ASK!!*** Staff would rather answer questions than fix broken equipment. Use other lab users as a resource.
    c. Pay particular attention to sources of particulate and chemical contamination.

DISCIPLINE

The above write-up is intended to provide information and guidelines necessary to keep the lab running smoothly. Many of these guidelines are simply common sense and require consideration of the other laboratory users. Others require specific knowledge of either proper equipment use or of chemical handling and safety. It is ***YOUR*** responsibility and obligation to be trained in on a particular piece of equipment or to be aware of correct chemical handling procedures. If you do not have these skills, learn them from lab staff before performing the task.

The guidelines are subject to revision dependent upon laboratory procedural changes. Be aware of new or changing lab guidelines.

Please encourage proper lab usage among the other lab users and report any serious violations of the guidelines to lab staff.

The following procedure will be used to discipline offenders in the laboratory. For each offense by a particular individual which is deemed unique by the safety officer, the following three step system will be used:

First Offense:	The safety officer will contact the individual to determine the details of the incident. Written warning to lab member and faculty advisor. Generally no loss of access privileges, but more serious first offenses will be disciplined more severely.
Second Offense:	The individual would meet with safety officer, lab manager, and advisor. After discussion the details, the corrective action will be decided by the MNC lab manager. This action may include suspension of lab use for a minimum of 1 week.
Third Offense:	Loss of access privileges permanently from the laboratory.