

Pritzker Nanofabrication Facility

Chemical Hygiene Plan

&

User Manual

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PNF Safety Procedures

1 Scope

This manual is for the operation and procedures in the Pritzker Nanofabrication Facility (PNF) at the University of Chicago (UChicago). This manual covers both safety and operating policies and procedures. Understanding and following these rules is required for all users of the PNF. While this policy cannot cover all possible cases, it is also expected that users will be able to exercise common sense when following the instructions of this manual. Users who do not act in a safe manner will have their access restricted, suspended, or revoked at the sole discretion of the PNF management. Please feel free to give feedback to the PNF staff on equipment, policies, and operations.

2 Basic Safety Statement

It is the responsibility of all users and staff to act in a professional, courteous, and safe manner at all times while in the facility. Users violating the operating and safety rules of the facility or endangering the safety of themselves or other users will have their access restricted, suspended, or revoked at the sole discretion of the PNF management.

Users are expected to be awake and alert at all times while in the facility. Sleeping in any of the clean room area will result in a suspension of PNF access. Additionally, running in the PNF, rough play, or other disruptive actions will not be tolerated and may result in suspension of PNF access.

All operations must be undertaken with the safety of both the individual user and other users as the primary consideration. As a general rule, anyone violating any safety rule or otherwise compromising his or her personal safety or the safety of others will be denied access to the PNF. Suspensions may be for a day, several days, a week, or permanently. These suspensions are at the sole discretion of the PNF management. Ignorance of the rules, lack of common sense, language difficulties, carelessness, and being short on time are not adequate excuses for unsafe behavior. In general, if a user is not certain on what the proper procedure is for something, it is better to stop and ask PNF staff than to try and guess what to do.

For the most part, rules on chemical use are formulated on the basis of basic chemical knowledge, the properties of individual chemicals, and common sense. There are extensive state and federal laws covering chemical use in the workplace and disposal of waste. Our rules are not restrictive or unnecessary, but are required to maintain safety in a shared facility with many users. Even with our extensive rules and staff supervision, the primary responsibility for safety rests with the individual user.

The user assumes responsibility for your work in the PNF and must always 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 if you are unsure. The PNF operates effectively when everyone is

cordial, follows instructions, and communicates.

In order to access the PNF and use specific tools, a laboratory user must successfully complete all of the training listed below. PNF staff members have the final say if someone is adequately trained to work in the PNF, but users are encouraged to ask any questions they may have regarding use of the PNF and the tools, and other resources in the facility.

- General University Chemical Hygiene Plan (2012EHS14)
- Fire and Evacuation (2016EHS40)
- PNF Specific Chemical Hygiene Plan and User Manual (this document)
- PNF CHP Quiz (2016PNF01)
- Tool, process and bench specific training, as required

2.1 Visible and Audible Alarms in the PNF

The facility can have many different types of emergencies. Although it is not possible to plan ahead for every type of possible emergency, the following sections cover the main types of emergencies that may occur with the appropriate response for each. Additional types of local alarms will be covered in each tool or bench specific Standard Operating Procedure (SOP). Overall building emergencies are covered in the Eckhart Research Center Emergency Action Plan.

2.1.1 Fire Alarm

White strobe with audible alarm, located throughout the PNF, will sound. If this alarm activates, immediately leave the PNF through the nearest exit and proceed to the designated evacuation point outside of the building. Do not remove bunny-suit until outside. Refer to ERC Building Evacuation Plan for further details.

2.1.2 Toxic Gas Alarm

Toxic gas alarms are located throughout the PNF. The alarm is indicated by **blue** colored strobe and indicates that the PNF must be evacuated. When this alarm is activated, all PNF users and staff should immediately proceed to the ERC first floor lobby from the nearest exit. During normal business hours, once users have confirmed with staff that they are safely outside the PNF, they are free to leave or remain in the lobby until the alarm is cleared. PNF staff will direct students as to when it is time to re-enter the cleanroom. After normal business hours, students should not re-enter the PNF under any circumstances until directed by a PNF staff member, *even if the alarm has cleared*.

2.1.3 Wet Bench Alarms

Small illuminated visual and audible alarms with buzzers will sound. Each wet bench may have multiple alarms, with a placard beside the alarms indicating meaning of alarm and proper response. You must follow the proper response if you see or hear a wet bench alarm.

2.1.4 Equipment Alarms

Please notify the Equipment Manager (EM) responsible for the tool or another PNF staff member if an equipment alarm is activated.

2.2 Medical Emergencies and First Aid

In medical emergencies, administer first aid, etc. as appropriate. If emergency assistance is needed, contact the University of Chicago Police Department from any campus phone by dialing 123.

If you believe you may have been exposed to a toxic substance or gas, if appropriate, rinse in the emergency shower. In all cases, quickly go to the emergency room at the University Mitchell Hospital, entrance located at 58th and Drexel Avenue, 773-702-6250.

Emergency safety showers and eye wash stations are located at the end of the three central chases. A first aid kit is located in the gowning room. Chemical spill clean-up kits are located on the wire shelving in each bay containing a wet bench. A separate HF spill kit is located by the HF wet bench. Follow University procedure in deeming what types of spills are appropriate to be cleaned up by the user versus emergency personal. After using a spill cleanup kit, please inform the PNF manager. After using an HF spill kit you must seek medical attention. Fire extinguishers are located on the south end of each clean bay, and the north end of each maintenance chase.

In addition to normal emergency response, all accidents involving chemicals and all accidents involving personal injury must be reported to the facility management in writing as soon as possible after the incident. Explanations should include the nature of the event, the procedures being followed or not followed at the time, and actions required to prevent future similar incidents. The PNF managers or the Laboratory Safety Specialist will supply a form appropriate for these reports. In addition, for cases involving personal injury to employees, the university may require additional documentation.

2.3 Special Health Hazards

2.3.1 Pregnancy

Although the PNF has invested significantly in engineering and work practice controls, 100% containment is not possible and many hazards are not fully understood for individual chemicals. Research has shown that users working with photolithography chemicals are at a higher risk for pregnancy complications. It is strongly recommended that users who are pregnant or are planning on getting pregnant do not work in the PNF. We encourage all users in these situations to discuss laboratory use with their physicians.

2.3.2 Pacemakers

Equipment in the lab may serve as sources of high voltage, ionizing radiation, ultrasonic interference, or electromagnetic interference, which may affect normal operation of a pacemaker. If you have such a device, you should consult your physician before working in the lab.

2.3.3 Allergies

Certain chemical compounds may trigger allergies in sensitive individuals. One common sensitivity is to latex, found in the cleanroom gloves. Vinyl (PVC or Co-Polymer) and nitrile cleanroom gloves are provided and may be used in place of latex. Check glove compatibility charts located on the PNF website. Other chemicals in the lab may also trigger allergies. Learn to recognize the signs of contact allergic reaction (skin sensitivity, hives, wheezing) and act to identify and avoid future contact.

3 Chemicals and Hazardous Materials in the PNF

Hazards in the laboratory fall into two general categories. First, the facility uses a variety of compressed gases, some of which are toxic, highly toxic, corrosive, flammable, or explosive. The use of these gases is thus strictly regulated as an accident with any of these could be catastrophic. These hazards, however, can and have been minimized by the proper use of engineering controls, such as use of proper equipment, proper confinement, ventilation, sensors, purges, safety valves, etc., and by procedural controls implemented by the staff.

The second, more troublesome category of hazard, concerns wet chemicals, i.e. the acids, bases and solvents commonly used in lithography and etching. These are “hands on” hazards and in a multi-use facility like the PNF, are hard to control by engineering. It is precisely because they are considered “ordinary” by many users that they present a serious hazard. The chemicals commonly used in the facility can cause severe burns, tissue damage, organ damage, asphyxiation, and genetic damage if improperly used. These chemicals can enter the body by inhalation, ingestion, or absorption (either directly through the skin or through gloves) and may have either long or short-term health consequences. In addition, improper use of solvents can result in a major fire. “Ordinary” chemicals are thus definitely not hazard-free. Users are expected to treat all chemicals with appropriate respect and to be aware of all possible reactions which may be created, either intentionally or by accident. The PNF has broken down liquid chemical hazards by both class and by individual chemicals that have specific handling procedures or are considered particularly or highly hazardous. Never interact with any chemical or other material unless you explicitly know what it is and understand the proper handling procedures.

Don't work if you don't know.

3.1 Definition of a Chemical

Chemicals, from a regulatory perspective, are defined as any material that is not a common household item. Therefore, in addition to the common acids and solvents we traditionally think of as being chemicals, industrial grade cleaners, soaps, adhesives, lubricants, etc. are defined as chemicals as well. The PNF is limited in the amounts of certain chemical classes that can be in the facility at one time per local regulations. Therefore, users should make every attempt to limit the volumes of chemicals brought into the facility to those in which they will need for their immediate work. Users need to keep this in mind when bringing new materials into the facility. All new materials require prior written approval of the PNF technical director.

3.2 Classes of Chemical Hazards

At PNF, liquid chemicals are categorized into six general chemical hazard classes: corrosive, oxidizer, air/water reactive, flammable, toxic/poison, and non-toxic. Many chemicals fall into more than one class. It is essential that you recognize the chemical hazard class of all the chemicals you are using and understand the appropriate measures required for safe use. Lab benches are designated for use of specific categories/chemicals and are designed for safety and compatibility. It is important not to use chemicals outside of their designated work areas. The following are the usual safety measures for handling any liquid chemical:

1. Know the main hazards and proper disposal method of the chemical you are using.
2. Use protective gear (safety goggles and face shield, tested and resistant gloves, chemical apron when appropriate) to prevent direct contact with the chemical.

3. Work only in an appropriately exhausted hood area to prevent inhalation.
4. Know the location of the nearest safety shower and eyewash station. These are located at the east end of Chases 3, 4, and 5.

3.2.1 Corrosive

A corrosive (or "caustic") chemical destroys or permanently damages living tissue. On contact, corrosives can destroy skin and underlying tissues. Splashes in the eyes can cause blindness. Inhalation of vapors can destroy lung tissue. Corrosives in the lab include acids and bases which are primarily used and stored in Bay 6. Mildly corrosive developers can be utilized in Bays 3 and 4 in appropriate benches. The following emergency procedures should occur for all corrosive exposures, **except for HF exposure** (covered in section 3.3.2): In case of localized external exposure, promptly flush the affected area with plenty of water, for at least 15 minutes. For more general external exposure, use a safety shower (see section 2.2). Remove clothing while under the shower and flush for at least 15 minutes. Exposure of corrosives to the eyes is extremely serious; flush immediately at the nearest eyewash station. Eyes should be rolled up and down, and side to side, continuously, to allow clean water to flush behind the eyeball. When using safety showers and eyewash stations, water will spill onto floor of the PNF - this is okay. For any exposure to corrosives, you should get help. The victim should be taken to the emergency center for evaluation and treatment.

3.2.2 Oxidizer

An oxidizer is a chemical compound that has a pair of electrons to donate to an electron-accepting, reducing agent. Often, they contain reactive oxygen. When mixed with compounds that can act as reducing agents, the result is often a violent reaction, possibly an explosion. Oxidizers should not be stored or mixed with solvents, which generally make excellent reducing agents. At PNF, oxidizers are located in Bay 6. One oxidizer is hydrogen peroxide (H_2O_2). Nitric acid (HNO_3) is an oxidizer as well as a corrosive. In the lab, the main principle behind segregation of chemicals is to keep oxidizers away from flammable chemicals (namely, solvents) and any combustible materials (some chemicals, materials like lab wipes) in order to reduce any hazards.

3.2.3 Water Reactive

Water reactive describes compounds which very quickly generate heat and/or gas upon mixing with water. These are often concentrated acids or bases. The primary hazard presented by water-reactive compounds is incomplete mixing, which can lead to superheating and explosion. Thus, water-reactive mixtures should never be poured directly into a sink drain. Aspirating water reactive mixtures at the wet benches is standard practice; the high dilution factor and rapid mixing dissipates heat and prevents superheating. Concentrated sulfuric acid and piranha etch are water reactive chemicals.

3.2.4 Flammable

Flammables include most solvents, such as acetone, isopropanol, and methanol. The "flash point" of a flammable is the concentration in air above which the vapors from a flammable can ignite and explode. The source of ignition may be heat (such as a hot plate) or a spark (such as from an electrical tool). Because the vapors can travel over considerable distances, the source of ignition can be far away from the flammables container itself.

To minimize hazards, always work well within the exhausted area of the appropriate bench. The

air pulled into the exhaust area will keep the concentration of vapors below the flash point. Due to both safety concerns and City of Chicago-specific regulatory concerns, the quantities of flammables used should be minimized. Before working with flammables, always note the location of the nearest safety shower and fire extinguisher. Flammables should be placed in the designated flammables cabinet located in Bay 3. Flammables must be kept away from oxidizers.

3.2.5 Toxic/Poison

A toxic material is one that has poisonous or harmful effects. There are formal, quantifiable definitions as to what comprises a toxic material and to what degree it is toxic. These definitions are based on lethal dosages for lab animals when administered orally or through inhalation. At the PNF, we work with a number of toxic liquids and gases.

3.2.6 Non-toxic

A non-toxic material is one that is not likely to result in harmful effects with normal use. This designation is used sparingly. Pure water is considered non-toxic.

3.3 Specific Chemical Liquid Hazards

3.3.1 Acetone and other solvents

Acetone is widely used throughout the facility. It is a very flammable solvent with a low flash point, (i.e. it can be ignited at a low ambient temperature). Because of this it presents a significant fire hazard. Under NO circumstances may flammable solvents be heated in the PNF beyond designated control areas. A spill of a gallon bottle of acetone could cause a catastrophic fire or explosion. Solvents should also be handled with care in the hoods and not used near hot plates. Spilled solvent can be ignited by the hot plates. The resulting fire could easily be drawn up into the exhaust ducts, again with catastrophic consequences. Spilled solvents can react explosively with chemical oxidizers present, (e.g., peroxides, nitric acid). Spilled solvents should be contained immediately with spill control pillows. 123 should be called for emergency response and to assist in clean up.

3.3.2 Hydrofluoric Acid Safety and Exposure

3.3.2.1 HF Exposure to Skin

Any exposure to HF or other fluoride-ion-containing solution must be treated immediately, as fluorine ions will quickly penetrate skin to damage tissue underneath. Concentrated HF will immediately cause extremely painful burns on contact. However, more dilute HF solutions will not cause any pain; yet can still cause deep tissue or systemic damage. If contact with HF (or related solution) is suspected, treat the incident as an HF exposure.

Response Procedure

1. IMMEDIATELY rinse the affected skin area with lots of water. Being careful to wash the acid away from other parts of your body, especially finger/toe nails where acid can get trapped. Speed and thoroughness in washing off the acid is of primary importance.
2. Remove all clothing exposed to the HF.
3. Continue rinsing for 1-2 minutes. Do not rinse for more than 5 minutes. Do not dry the skin.
4. Call for help.
5. Obtain Calcium Gluconate gel (available at all HF wet benches in the lab).
6. Puncture the tube using the inverted tube cap. Apply gel over the entire affected area.

7. Double glove with nitrile gloves and gently massage the gel into the skin. Take the gel with you and continue to apply fresh gel while en route to the Emergency Room.
8. Elevate burned extremities, if possible.
9. **Seek immediate medical attention by calling 123.**
10. Tell them you experienced direct exposure to Hydrofluoric Acid.
11. Continue to apply fresh gel (and gently massage it in) while waiting to be treated.
12. Following treatment, the injury must be reported to a PNF manager.

3.3.2.2 HF Exposure to Eyes

Immediately rinse exposed area for 15 minutes at eye wash station. Hold eyelids open during irrigation to allow thorough flushing of the eyes. Move eyeballs back and forth to remove any HF behind the eyes. **Seek immediate medical attention by calling 123.**

3.3.2.3 HF Ingestion Exposure

DO NOT INDUCE VOMITING. Give Milk or Water. THEN give Milk of Magnesia or 8-12 Tums or Rolaids. **Seek immediate medical attention by calling 123.**

3.3.3 Piranha Etch and Nanostrip

Piranha etch is a common name applied to a mixture of Hydrogen Peroxide and Sulfuric Acid (typically 1:5). It is extremely aggressive toward organic materials (e.g. flesh and photoresist residue, equally). It also removes heavy metal contamination. It is commonly used in the semiconductor industry for wafer cleaning. However it is difficult to properly dispose of this mixture as the waste continues to react and decompose for a long period of time. This builds up pressure in the waste bottles causing them to burst. Also if the solution is a very peroxide-rich mix, it may create unstable compounds. Therefore, piranha is not allowed to be mixed in the chemical hoods. Instead of piranha etch, the facility stocks Nanostrip, a commercial stabilized version of piranha. Users of the PNF are only allowed to use Nanostrip once they have received express written permission from the PNF management.

3.3.4 TMAH Safety and Exposure

TMAH is a component in several photoresist developers and strippers, and is also used in the PNF as an e-beam resist developer and silicon etchant. The concentration of TMAH in photoresist developer and stripper solutions is relatively low (2-4%). However, the e-beam developer and silicon etchant utilize a solution of 25% TMAH.

3.3.4.1 TMAH Exposure to Skin, 25% Concentration

Immediately rinse exposed area for at least 15 minutes in safety shower, flush affected area thoroughly. An enclosed emergency shower is located at the east end of Chase 4, across from the HF/TMAH wet etch bench. If using the emergency shower at the end of the chase, water will spill onto floor of the PNF - this is okay.

Seek immediate medical attention by calling 123 from a campus phone.

3.3.4.2 TMAH Exposure to Skin, 2%-4% Concentration

For small area skin exposure (<1% body surface area, <25 inches²) to 2-4% TMAH, immediately rinse exposed area until skin feels normal (not greasy). If irritation occurs, consult a physician.

For medium to large area skin exposure (>1% body surface area, >25 inches²) to 2-4% TMAH, immediately rinse exposed area for at least 15 minutes in a safety shower, to flush the affected

area thoroughly. Emergency showers are located at the east end of Chases 3, 4, and 5. An enclosed emergency shower is located at the east end of Chase 4, across from the HF/TMAH wet etch bench. When using the emergency shower or eyewash station, water will spill onto floor of the PNF - this is okay. **Seek immediate medical attention by calling 123 from a campus phone.**

3.3.4.3 TMAH Exposure to Eyes, Any Concentration

Immediately rinse exposed area for at least 15 minutes at eye wash station. Hold eyelids open during irrigation to allow thorough flushing of the eyes. Water will spill onto floor of PNF - this is OK. **Seek immediate medical attention 123 from a campus phone.**

3.3.5 Chlorinated Solvents

Chlorinated solvents (chlorobenzene, trichloroethylene, and methylene chloride) are used in various resist processes. They are particularly damaging to the human body, potentially causing cancer, organ damage, etc. They should not be mixed with normal solvents in waste bottles. There are separate waste bottles for chlorinated solvents. As with most solvents, they can be readily absorbed through the skin. Rinsing of containers that contained chlorinated solvents requires a special procedure to ensure the material is completely removed. This SOP will be posted in relevant locations in the PNF, including our website. Please familiarize yourself with the SOP if you are using chlorinated solvents.

3.3.6 Hydrogen Peroxide

Hydrogen peroxide is a strong oxidizer that has the potential to cause a fire or explosion when in contact with incompatible materials. It is corrosive. It is toxic if swallowed. It may be harmful if inhaled or absorbed through the skin. High concentrations of hydrogen peroxide (>30%) must not be used outside of designated areas.

3.4 Specific Gaseous Chemical Hazards

In compliance with City of Chicago regulations, most of the common hazardous gases used in the PNF are piped from a storage room located on the ground floor of the ERC. For safety reasons, only PNF staff are allowed to connect any project-specific gases needed by the user within the PNF facility.

3.4.1 Silane

Silane (SiH_4) is used for the deposition of polysilicon, silicon nitride, and silicon dioxide in the MOS area and PECVD systems. Silane is pyrophoric, meaning it will spontaneously ignite in air at concentrations between 4% and approximately 90%. The silane gas cylinder is located in a ventilated cabinet and the bottle is fitted with a flow-restricting orifice and a flow limit valve. These limit the flow of gas from the bottle so that even under catastrophic system failure the concentration is kept below the lower explosive limit.

3.4.2 Chlorine

Chlorine gas is used in several of the etching systems. Chlorine is severely corrosive and is harmful when inhaled. Chlorine forms HCl in the lungs, causing severe tissue damage which can be fatal. As with many other corrosive gases, the effects of exposure may not be noticed for a few days. In all cases, medical attention should be sought immediately following exposure, not at the onset of symptoms.

3.4.3 Anhydrous HCl

Anhydrous HCl (HCl gas) is extremely corrosive to almost everything, including stainless steel. Symptoms of exposure are similar to chlorine.

3.4.4 Anhydrous Ammonia

Anhydrous Ammonia (NH₃) is a severely corrosive alkaline vapor with a pungent odor. It is shipped in the cylinder as a liquid under its own vapor pressure, approximately 9 atm. It exhibits good warning properties, with an odor threshold of 50 ppm. Although the TLV is only 25 ppm, concentrations up to 300 ppm can be tolerated for an hour. Concentrations above 3000 ppm are suffocating, causing convulsive coughing and respiratory spasm. Such exposures can rapidly be fatal.

3.4.5 Phosphine

Phosphine gas is a severe pulmonary irritant and an acute systemic poison. Overexposure can cause either sudden or delayed death due to lung destruction. It is a colorless gas with a fishy odor. Olfactory (smell) warning properties are better, however, than for arsine or diborane. It is toxic at levels near the odor threshold so it must be treated with great care.

3.4.6 Diborane

Diborane (B₂H₆) is a colorless gas with a repulsive sweet odor. It acts as a pulmonary (lung) irritant. It is considerably lighter than air. The OSHA permissible exposure limit is 0.1 ppm averaged over 8 hours. Odor is not a reliable indicator of danger. Like phosphine and silane, it is pyrophoric. Fires involving diborane can produce other toxic fumes. The diborane used in the facility is diluted to 0.2 % in helium in the bottle. This significantly reduces the danger associated with an accidental release.

3.5 Other Specific Hazards

3.5.1 Electrical Hazards

Electrical shock hazards are present wherever electricity is used. Although equipment is interlocked to prevent operator exposure, you must be aware of the electrical hazards for the tool you are using. Burns occur wherever the body completes a circuit connecting the power source with ground. Although the resistance of dry, unbroken skin to electric current is relatively high, the amount of current needed to kill a person is small. It is easy to exceed lethal levels of current, especially if the skin is broken, wet, or damp with sweat.

Unless you are trained to do so, never open electrical enclosures or cabinets on equipment, even when the power is off. If you feel an electrical "tingle" when you touch a piece of equipment, stop using the tool and immediately notify a PNF staff person. Never stick your hands, fingers or conductive tools inside equipment. Immediately notify PNF staff of any potential electrical hazard that you notice.

3.5.2 Ultraviolet Radiation

UV exposure is a potential risk in plasma etch, plasma deposition, and sputter tools, where highly energized species are generated. High power UV lamps are used in the aligner and stepper tools in photolithography; as they are mercury-based, they pose a chemical risk. If a UV

lamp should break or explode, do not attempt to clean up; instead, isolate the immediate area and call PNF staff.

3.5.3 Cryogenic Hazards

Cryogenic hazards are presented by liquid nitrogen ("LN2"). Liquid nitrogen is 77 °K or -196°C and can cause freezing burns. Do not handle liquid nitrogen unless your equipment training covers it. Always wear protective gear (thermally insulated gloves and goggles) when handling liquid nitrogen.

3.5.4 Electromagnetic Radiation

Electromagnetic radiation may be generated by equipment using RF (primarily plasma etch and plasma deposition tools.) If you have a pacemaker, be aware that RF sources are present in the lab. All equipment is shielded to prevent exposure; report any damage to shielding on the equipment or cables.

3.6 New Chemical Authorization

Because of the large number of users in the laboratory, the facility keeps a close tab on chemicals used in the laboratory. Only specifically authorized chemicals may be used in the laboratory. Most standard processing chemicals have been pre-authorized; Safety Data Sheets for these are available on the [PNF website](#). No other chemicals may be brought into the facility until they have been approved, no exceptions.

The PNF Technical Director may issue approval for a new chemical based on a review of the SDS and other relevant information provided by the user. To submit a new chemical for review, submit a [Chemical Request Form](#). Approval of new chemicals is not guaranteed; new chemical requests may be turned down if they are too hazardous or are incompatible with other use of the laboratory. The approval process can take time as chemical compatibility, waste disposal, and other issues must be resolved. Researchers should plan accordingly when needing new chemicals approved. Do not bring any chemicals or have them shipped to the PNF prior to receiving written approval. You will be expected to know the main hazards, handling requirements, and disposal methods for any chemical you use in the lab.

3.7 Chemical Safety Information

3.7.1 Safety Data Sheet

The Safety Data Sheet (SDS) is a convenient, condensed source for information on the properties of any chemical. The SDS is a federally mandated document which must be supplied by the manufacturer or seller of a chemical. It contains in summary form, the chemical composition, the physical and chemical properties, toxicology data, and instructions for handling, spill control, and waste disposal. As a matter of good habit, users are expected to read the SDS for every chemical that they handle. Safety Data Sheets for all chemicals approved for use in the laboratory are available on our website [Chemical List](#).

3.8 Chemical Container Labeling

Chemical containers such as beakers, bottles, etc, must be labeled with contents, date, and ownership (individual or group name). This information can be written directly on the container and/or lid, or on a wipe under the container.

Other chemical containers are required to have a label provided by the manufacturer, which in addition to composition, contains the following precautionary information

- A signal word, which is one of the following: “Warning” or “Danger”, indicating potential for hazard. “Danger” indicates a greater hazard than “Warning.”
- One or more Statements of Hazard, which describe in more detail the hazard presented.
- Precautionary Measures.
- First Aid or other information (this may not always be present on the label.)

Remember, only chemicals in their original containers will have these labels. Chemicals that have been dispensed for use or into other containers may not have this information, and it is the responsibility of the user to add this information to any secondary container.

3.9 Chemical Storage

Due to local regulations, chemical storage is strictly regulated in terms of class and volumes. Large volumes of typically-stocked chemicals are stored above ground and either piped in (gases) or brought down daily by PNF staff. Users should make attempts to limit volumes of chemicals they may be bringing in for their own personal use to what is immediately needed.

3.9.1 Acid Storage

The primary acid storage area (except HF) is the acid cabinet located next to the acid wet processing benches in Bay 6. HF acid is stored in the HF cabinet.

3.9.2 Base Storage

The primary base storage area is the base cabinet located next to the acid wet processing bench in Bay 6.

3.9.3 Solvent Storage

The primary solvent storage area is the stainless steel flammables cabinet in Bay 3. There is also flammable storage in the refrigerator in Bay 3 and freezer located in Chase 4.

3.10 Chemical Waste Disposal

The correct method of disposal for any chemical waste in our inventory is posted throughout the PNF, and also indicated in a file titled “PNF Chemical Storage/Use/Disposal”, located on the desktops of all optical microscope computers in the PNF. **DO NOT DISPOSE OF SOLVENTS IN THE ACID DRAIN, OR ACIDS AND BASES IN THE SOLVENT DRAINS DUE TO POSSIBLE EXPLOSION OR THE CREATION OF OTHER HAZARDOUS SITUATIONS.**

3.10.1 Acid Drains

The acid drain empties into a waste chemical pH neutralization system located in the PNF Acid Waste Neutralization (AWN) room. This is the primary drain in the PNF. All liquids entering the sink drain at any designated acid or base bench in the PNF run through this treatment system. Chrome Etch must not be disposed of in the acid drain, and should be disposed of separately in local collection.

To dispose of an acid or base, pour the liquid down the drain using the plenum flush. If you spill an acid or base onto the top surface of a bench, first rinse the surface thoroughly with water, then turn on the plenum flush to rinse the bench drain.

Do not dispose of solvents in the acid drain due to possible explosion or the creation of other hazardous materials.

When disposing of wipes that may be contaminated with acid, please make sure to dispose of them properly. You may put them in the neutralization tank, in the wet bench where you are working. Or, rinse the wipes three times in the sink and dispose of the wipes in the general trash.

3.10.2 Solvent Drains

Standard, non-halogenated solvent waste is collected into the solvent waste drains at the solvent wet benches (SOL1 and SOL2) and pumped up to the HPM. The standard solvents are: methanol, isopropanol, and acetone. Standard solvent waste includes these chemicals and photoresist waste. Solvent-contaminated wipes and other solvent solids must be disposed of in the solid solvent waste container located at the solvent wet benches (SOL1 and SOL2). Do not put halogenated waste into the solvent waste collection tank (see below).

3.11 Local Collection

Some chemicals used at PNF cannot be disposed of using the AWN, or the general solvent waste collection tanks. PNF approved local collection tanks will exist in a few locations. Said locations will be appropriately marked and only these chemicals are to be disposed of in this manner. When a user's chemical is approved, an appropriate disposal plan will be discussed and approved at that time. Users must contact the appropriate PNF staff member if the local container needs disposal.

3.11.1 Disposal of Empty Chemical Containers

For the safety of fellow users and janitorial staff, users of the PNF are not allowed to dispose of empty chemical containers. All empty chemical containers should be placed in the appropriate location, typically in the flammables cabinet in chase 4 or the acid cabinet in chase 7, clearly marked as empty, and our staff will dispose of them appropriately.

3.12 Shipping Chemicals

If a user is shipping approved chemicals to the facility from their own institution or supplier, it is important that they are shipped following all applicable Department of Transportation (DOT), International Air Transport Association (IATA), and International Maritime Dangerous Goods (IMDG) laws for hazardous shipments. Users should check with their home institution's Environmental Health & Safety (EH&S) organization or their supplier for more information regarding shipping chemicals. All chemicals should be shipped to the PNF for staff to transport into our facility.

3.13 Transporting Chemicals

University of Chicago policies govern the transport of all chemicals, including in all public areas of the PNF such as the office and gowning areas. Users may not carry any particularly hazardous chemicals nor any chemicals in volumes greater than one liter into the facility. All

transporting of particularly hazardous chemicals and chemicals in volumes greater than one liter into the PNF, must be done by staff. All hazardous chemicals and chemicals in volumes greater than one liter should be delivered to the ERC loading dock where a staff member can then transport the material through the Hazardous Material Corridor (HPM) and down to the PNF. A PNF staff member will then place the material into the appropriate area within the PNF for the researcher to utilize.

3.14 PNF Personal Protective Equipment Policy

The PNF provides typical PPE for all users. Users are allowed to wear their own PPE, provided it meets the minimum standards of the PPE in the PNF and meets current ANSI standards. Users are expected to always use the appropriate minimum PPE at all times in the PNF as outlined by this document. More stringent PPE requirements are outlined in specific tool or bench procedure SOPs.

PNF Gloves and Aprons

Always wear gloves when in the PNF, double gloves are recommended. Gloves protect your hands and are equally important in protecting your work from contamination. Never touch your face. Always change gloves when moving from one tool, work area or piece of equipment to another. If you return to the gowning area for water, remember to put on clean gloves before drinking. Always wash your hands after removing your gloves and exiting the cleanroom.

Acid aprons are required when handling HF and other highly corrosive or toxic chemicals. Please do not wear acid aprons while working in other areas of the PNF.

Five types of gloves are available in the PNF as outlined in the table below:

| Material | Manufacturer/Model | Color | Thickness | Stocked Sizes |
|----------------|-----------------------|-------|-----------------|--------------------|
| PVC | Kimtech G5 Co-Polymer | Clear | 4 mil (0.10mm) | S, M, L, XL |
| Latex | Kimtech G3 Latex | Tan | 8.7 mil | S, M, L, XL |
| Nitrile | Kimtech G3 Nitrile | White | 5.1 mil | XS, S, M, L, XL |
| Nitrile | MAPA StanSolve A-30 | Green | 11 mil (0.28mm) | 7, 8, 9, 10, 11 |
| Blend | MAPA TRIonic E-194 | Tan | 20 mil (0.50mm) | 6, 7, 8, 9, 10, 11 |

Polyvinyl Chloride (PVC): Kimtech G5 Co-Polymer

A relatively inexpensive static free general-purpose glove, poor for most organics. These gloves break down rapidly in acetone.

Latex: Kimtech G3 Latex

A general-purpose glove, poor for most organics, okay with aldehydes and ketones.

Nitrile, White: Best CleaN-Dex Ultimate

This thin general purpose low cost glove offers marginal protection from many keytones, okay with some acids and bases.

Nitrile, Green: MAPA StanSolve A-30

A thicker nitrile glove that affords increased protection over the Clean-Dex white nitrile glove.

Nitrile/Neoprene/Latex Blend: MAPA TRIonic E-194

This glove is the standard corrosive wet processing glove. A blend of latex, neoprene, and carboxylated nitrile, which offers excellent protection from corrosives and solvents such as HF and acetone. This glove is also highly resistant to cuts, tears, and snags. Always use this glove when processing with HF, TMAH, or Bromine.

3.15 Eye Protection

ANSI-approved eye protection must be worn at all times in the PNF, except when using optical microscopes. All eye protection eyewear must be ANSI-approved, as indicated by the “Z87” stamp required on the eyewear. You are welcome to use personal prescription safety eyewear which is ANSI-approved. Four types of safety eyewear are stocked in the PNF:

Kimberly-Clark Professional Jackson Safety Nemesis Eyeware (25676)

For use by people who do not wear vision correction glasses. These safety glasses have a black frame.

Fisherbrand 200 Series Spectacles

For use by people who do wear vision correction glasses. These safety glasses are intended to be worn over vision correction glasses, and have a blue frame.

Uvex® OTG Stealth® Safety Goggles S20753**BioClean Clearview™ Sterile Cleanroom Goggles****Kimberly-Clark™ Professional Jackson Safety™ MonoGoggle™ XTR**

These safety goggles have a grey frame and can be used with or without corrective lenses. Always use goggles when working at the acid or base benches.

Fisherbrand™ Faceshield**Oberon™ Face-Fit™ Chemical-Resistant Faceshield**

One of these full faceshields must be worn with safety goggles when working with dangerous chemicals or materials. A faceshield is mandatory when working at the HF bench.

3.16 Respirator Use Policy

In general, engineering controls (fume hoods, equipment interlocks, etc) in the facility are sufficient to prevent the need for users to use a respirator. Respirator usage is tightly controlled by OSHA, as improper usage can lead to a false sense of safety and a greater chemical exposure than without one. Users who feel that they would benefit from the use of a respirator in the facility should discuss it with the Safety Manager to determine if it is appropriate.

PNF Facility Procedures

4 PNF Facility and Policies

4.1 Website

Up-to-date information about the PNF can be found at our website, <http://pnf.uchicago.edu/>. The website has links to get started as a user, access our online management system, get information on equipment and processes, contact staff, and to download forms (User Agreements, Chemical Request, etc.).

4.2 PNF Access and Orientation

The process and requirements for access and training to use the PNF are outlined on our website, <http://pnf.uchicago.edu/>. Access to the PNF requires a UChicago Card or a Campus Card from ID & Privileges Office, along with authorization from the PNF management team. A CNetID from IT Services is required to access the UChicago training required to become an authorized user of the facilities. A login for the facilities management software, [UChicago FOM](#) is needed to schedule training for the PNF facility and equipment. Safety and orientation training is required of all new PNF users. Additional training that is required for specific tools and processes is provided by PNF staff as needed. This training can be scheduled through our facilities management software.

4.3 Using the PNF

Users are classified as either UChicago (internal faculty, staff, students, or business unit using a UChicago account number for billing) or external (no UChicago account for billing). External users are further categorized as academic (other academic institutions, US government offices and agencies, and certified nonprofit organizations) or industrial (all other for-profit organizations). As a user facility, the most common paradigm is for individuals to process their devices in person (onsite users). An alternative approach is remote use, where facility staff will conduct limited scope fabrication processes on behalf of the user (remote users).

4.3.1 Becoming a User

Before becoming a user, we suggest scheduling a meeting with PNF staff to discuss your project and be introduced to the facility. Next, you will need to start the [registration process](#) on our website, <http://pnf.uchicago.edu/>.

1. Write a short (up to 1 page) description of your research project and include a short description of your process steps. This can be submitted on the registration form or emailed to the Technical Director. This information is used to confirm that the PNF has the capabilities that you need and to ensure that materials that you will be using are compatible with other research being conducted in the PNF.
2. Complete and submit the user registration form to start the process to become a PNF user. If you are not already on the pnf-user listserv, you will be added to the listserv after submitting your registration form. Announcements and information of interest to

PNF users as well as any special training announcements are made to this list. For all external users, the PNF will start the process to get you set up with UChicago access. For internal users and users with an existing UChicago affiliation and CNetID, the PNF will confirm you have completed the required UChicago training:

- a. 2012EHS14 - Chemical Hygiene Plan (includes Personal Protective Equipment, PPE)
 - b. 2012EHS40 - Fire Safety and Evacuation
3. The PNF technical director (Peter Duda), will evaluate your research project feasibility and you will receive process design assistance if needed.
 4. New users will be given access to ERC LL1 where the PNF is located and will have an account created in FOM our Facilities Online Manager system.
 5. Review in detail this PNF CHP and User Manual.
 6. Attend a PNF specific orientation and safety class. Please contact the technical director, duda@uchicago.edu to schedule PNF training. Once you complete this training, are set up in FOM and are approved as a PNF user, you may request equipment specific equipment training through FOM.
 7. Read and sign the appropriate [user agreement](#), then submit the agreement to the Technical director for approval.
 8. Schedule a short meeting with your faculty or research sponsor and the technical director in order to review your research and complete your access approval. We will review your safety training records to ensure you have completed all necessary training, discuss your process and plan related training needs, then you will be issued your PNF access via your UChicago or Campus card.
 9. Schedule and complete training on specific equipment used for your fabrication process.
 10. Schedule equipment use via the [UChicago FOM](#).

This website will direct you through the above registration process. In short, the process involves determining your role (UChicago or external, remote, etc.), and then entering contact information, a scope of use proposal, and billing and financial data. After reading and understanding this User Manual, you must complete and return the appropriate Facility Use Agreement. Lastly, you will also be required to complete a variety of online and in-person training.

4.3.2 Onsite Users

Onsite users work in the PNF using our equipment and tools for their projects. While working at the PNF, onsite users learn a variety of processes and gain valuable skills. After a PNF orientation and wet bench training, users are able to sign up for specific equipment training as needed. The PNF advises new users to find a mentor or to consult with staff to ensure proper cleanroom technique, especially if the user is planning to repeat or expand upon an established process.

4.3.3 Remote Users

PNF staff are available to conduct limited-scope process work on a best effort, time and materials basis for remote users. Due to the experimental nature of most contract processes, the PNF cannot provide product guarantees, but will work closely with clients to determine project feasibility, to provide cost estimates, and attempt to obtain mutually satisfactory results. Remote users will be assessed a fee for sample shipping.

4.4 PNF User Communication

The main point of the communication with the PNF is our website, pnf.uchicago.edu and pnf-users@lists.uchicago.edu. Through our Facilities Online Manager, [UChicago FOM](#), the status of the tools and facility closures can be accessed. Additionally, the staff can be reached through the listed information in the [PNF staff directory](#) which you can see by scrolling down on our Contact Us page. Safety concerns should be reported by email or phone to Peter Duda, Technical Director, 773-702-8903 or duda@uchicago.edu.

4.5 Hours of Operation

The PNF is open with staff support from 8:00am to 5:00pm, Monday through Friday. Users approved for extended hours access may enter the PNF from 6:00am to 10:00pm daily. Restrictions may be placed on processes and equipment available to a user during evenings and weekend hours. Staff supported hours and operating hours may be restricted as needed.

4.6 Facility Closures

The PNF is available to users during staffed hours, 8:00am-5:00pm M-F. After hours use is available to qualified users most of the time, except University Holidays and limited other days when the facility is closed. Please check the PNF website [About](#) page and scroll down to see a schedule of operating hours and scheduled closures.

5 General PNF Policies

5.1 Priorities

5.1.1 Safety

You are responsible for your safety and for the safety of those around you. Do not work in the PNF when you are tired, sick, medicated, or intoxicated. Read and understand the safety information in this manual, in equipment protocols, and in chemical data sheets.

5.1.2 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 will be liable for property and equipment damages that may include staff time, spare parts, vendor services, or equipment replacement.

5.2 Access Cards

The UChicago Card or Campus Card provides secure access to the PNF, and allows tracking of the time each user spends in the PNF. ALWAYS swipe in when entering the lab, and swipe out when exiting the lab, even when attending training sessions or performing beneficial work. Violating this policy will result in a warning for the first incidence, and possible suspension from PNF access or other penalties up to permanent suspension, for recurring incidences. Users are responsible for having their cards available when they plan to use the PNF. Replacement cards are the responsibility of the user. Lost or stolen cards must be reported to the PNF Admin team immediately to prevent unauthorized use of the PNF, you must also email lostcard@uchicago.edu or stop by the ID & Privileges Office during business hours to

have it deactivated. Hours are M-Th 8:30am-6:00pm, Friday 8:30am-5:00pm, and Saturday 9:00am-1:00pm.

5.3 Single-Sign-On Credentials

Users may use UChicago CNetID, single-sign-on (SSO) credentials or another authorized ID for authentication in order to access some resources in the PNF such as Box file storage. Users must follow all University policies and acceptable use terms for their authentication credentials.

5.4 Dress Code

The PNF dress code applies to all PNF areas, except the viewing corridor. It is based on best practices for working in cleanroom areas containing hazardous materials, and emphasizes covering as much skin as possible to contain sloughed skin particles and protect users from chemicals. You will be denied access to laboratory spaces if you are not dressed according to the following rules.

5.4.1 Hygiene

You and your clothing should be clean (i.e. free of dust and/or dirt) before entering the PNF spaces. Avoid clothing that sheds fibers such as wool, fur, fake fur, mohair, etc. Dirty or shedding clothes contaminate everyone's work, even in non-cleanroom spaces. Make-up and cosmetics are not allowed in PNF spaces.

5.4.2 Shoes

Users and staff 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. Despite the substantial inclement weather in Chicago, your shoes should be clean and dry before entering the PNF. It is preferable that you bring a clean, dry change of dedicated PNF shoes that you do not wear outside. It is imperative that you avoid tracking mud, dirt and leaves into the PNF.

5.4.3 Pants

Users and staff 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.

5.4.4 Shirts

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.

5.4.5 Contact Lenses

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

5.5 Undergraduates

Undergraduate students, who have completed all of the requirements for PNF access, are allowed to use the PNF with some restrictions. For safety reasons, undergraduate use of, and access to the PNF is limited to staff supported operating hours from 8AM-5PM, Monday - Friday. Under special circumstances, with prior approval of the Technical Director, undergraduate students may be allowed to work in the PNF after-hours. As a safety precaution, an undergraduate who is approved for after-hours use of the PNF may not work in the PNF alone and must be accompanied by a buddy at all times.

5.6 Visitors

Visitors are not allowed in PNF spaces without approval. If you want to bring visitors into the PNF, you must contact the PNF staff at least two days before the visit. For each approved visitor you will be assessed a fee to cover cleanroom consumables. An active PNF user must escort each visitor during his or her entire time in PNF spaces and is responsible for the visitor's actions and safety. Visitors are to abide by all safety measures expected of PNF 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 to meet the minimum occupancy requirement.

5.6.1 Visiting Scholars

Visiting scholars should contact the PNF staff to receive a tour of the cleanroom. The same policy applies for sponsoring agencies, collaborators, and prospective researchers.

5.6.2 Interns

Whenever an intern is in the PNF, their mentor must also be in the PNF. Interns may use tools that do not require training sessions, such as microscopes, etc, unless the Equipment Manager (EM) of these tools objects. Interns can work at photolith benches, and use components of the photolith benches, unless the supervisor of the bench objects. Interns will need to follow normal PNF access procedures, including an initiation meeting with the PNF manager.

Interns will be allowed to use one or two mainline PNF tools after completing training conducted by PNF staff. Mainline tools are tools scheduled through our web site FOM. Certain tools will be unavailable to interns due to extremely heavy use or other concerns.

5.6.3 Minors

No minors are allowed in the PNF without special approval from the Technical Director. Approval must be requested in advance and for safety reasons, will only be given under limited circumstances.

5.6.4 Viewing Corridor

The viewing corridor is open to authorized users of the building and does not require gowning. Please contact PNF staff to set up a guided tour of the PNF from the corridor.

5.7 Allowed/Prohibited Items

To maintain a safe working environment, certain items are not allowed in the PNF spaces.

Below is a list of common items that are either allowed or prohibited in the facility. This list does not cover everything, so please check with PNF staff before bringing any item into the facility. This list only covers the PNF areas beyond the entry doors, and not the offices or computer rooms.

| Allowed Items/Activities | Prohibited Items/Activities |
|---|---|
| Cameras (no flash in yellow rooms) | Headphones |
| Laptops, PDAs, e-readers, music players | Food or drink, gum, cough drops, mints, etc. |
| Earbuds that allow user to hear all alarms and/or warnings | Smoking, chewing tobacco |
| Smartphones, mobile phones* | Cardboard, paper and pencils** |
| Cleanroom specific paper products | Offensive or obscene materials or media |
| Approved paper and pens | Cosmetics and make-up |
| | Paper towels, fabric towels handkerchiefs or tissues |

*LL1 of WERC has limited wireless and cellular access

**The only paper allowed in the PNF are types specifically developed for cleanroom use. We can recommend many different types of cleanroom specific paper for use in the PNF, including printer paper, sticky labels, and assorted notebooks. If you require a special type of paper, ask and we will try to find a source. You can laminate regular paper for use in the PNF. You are required to use approved pens, not pencils, for writing in the PNF.

5.8 PNF Recharge Billing

The PNF is a nonprofit business unit within the University of Chicago that charges time and materials on a cost reimbursement basis. UChicago Financial Services mandates an annual review of operating costs to ensure cost recovery. Rates are a function of cost of operation (labor and materials) and utilization; if the user base grows and utilization increases, costs decrease.

Due to the nature of work at the PNF, it is not possible to issue binding quotations for projects. Many projects have unanticipated changes in scope and processes based on experimental results, so for external users, a “not to exceed dollar amount” purchase order is recommended to allow flexibility with minimum delays. The PNF staff can assist with estimates as needed.

5.8.1 New User Fee

All users will be charged an initial registration and start-up fee. This fee includes access credentials, gowning, and all training for the facility and equipment.

5.8.2 Annual Renewal Fee

Users will be charged an annual fee to cover gowning costs.

5.8.3 Access Fees

There is an hourly usage fee charged for access to the PNF, this fee is higher during staff supported hours of 8:00am-5:00pm and decreases from 5:00pm-8:00am. This rate is charged for the elapsed time the user is in the PNF based on their swipe access to the entry/exit door.

5.8.4 Equipment Use Fees

The equipment and tools in the PNF are divided into five tiers. Tier 0 tools are included in the hourly access fee charged for entering the PNF. Tools in tiers 1-4 incur an additional hourly charge based on the elapsed time a user is logged in to use each equipment in tier 1-4.

5.8.5 Other Fees

Other fees include, but are not limited to, hourly charges for staff support, charges for precious or expensive materials consumed in a process, and penalties assessed for any damage by a user to the PNF equipment.

5.9 Citation Requirements

Please provide the PNF with critical support by always including the following acknowledgement when presenting and/or publishing results made possible with use of PNF:

“This work made use of the Pritzker Nanofabrication Facility of the Institute for Molecular Engineering at the University of Chicago, which receives support from SHyNE, a node of the National Science Foundation’s National Nanotechnology Coordinated Infrastructure (NSF NNCI-1542205).”

We depend on you to acknowledge our facilities as well as our staff. Equally important, always provide the PNF with citations for your publications that include work done at PNF.

5.10 Data Management

Any requirement for data generated in the PNF to be managed, archived or made available publicly is the responsibility of the user.

6 PNF Equipment

6.1 Equipment Capabilities

PNF equipment capabilities are outlined on our website, <http://pnf.uchicago.edu/equipment/>.

6.2 Equipment Policies

Access to the PNF does not of itself permit use of any particular tool. Each major piece of equipment has specific policies and procedures for use, including training requirements. All required training must be completed in order for a user to be granted access to that equipment. Because much of the equipment in the facility is highly complex and delicate, each piece of equipment has standard operating procedures and policies that are set by the staff to assure the continued operation of the equipment. Violation of these procedures or carelessness in operation can result in damage to the equipment, down-time and considerable expense. Consequently, careless or damaging use of equipment will result in suspension of user privileges, either for specific equipment or the facility as a whole. In addition, the user is expected to pay for damage caused by misuse.

PNF staff members are responsible for tool maintenance, training, and process development. The staff, along with facility management, determine the equipment policies regarding allowed

and prohibited operations on the tool. Each tool has instructions for user operation of the tool. These instructions may vary from a single sheet posted at the tool, to a more detailed manual, or a supplement to the operating manual provided by the original equipment manufacturer (OEM).

- Users must be trained and authorized before using any equipment in the PNF.
- Users must follow SOPs for all equipment in the PNF.
- Equipment can only be used for approved purposes.
- Users are required to report any and all equipment problems or damages

6.3 *Equipment Training Requirements*

Before using any piece of equipment at the PNF, users must be trained by staff who are authorized to train on that specific tool. Users cannot be trained by other users, or by staff not authorized to train on the tool. If you are ever uncertain, check with one of the PNF managers. It does not matter much how experience a user has with similar equipment, as our policies concerning the operations allowed may be different than other facilities. During a user's first visit, the hosting staff member will often run many of the pieces of equipment for the user to help the project make some initial progress. It is important to understand the difference between a staff member demonstrating how they are running the tool, and official tool training. Again, if a user is uncertain at any time, they should check with the staff member to determine if they are being trained on tool operation. Users accessing tools or other lab facilities acknowledge that they have received the prescribed training from an authorized PNF staff member prior to using the equipment.

When training is requested, the PNF staff will schedule training for users on equipment. Once the PNF staff is satisfied with the user's understanding of the operation of the equipment, the user will be authorized to use that equipment without supervision.

6.4 *Equipment Information Sheets*

Each major piece of equipment in the PNF will have an Equipment Information Sheet (EIS) posted on the tool and on our website. The sheet is a single page summary sheet of important information regarding the tool. It lists the staff members in charge of the tool, highlights important safety information including any buddy requirements, processing and material restrictions, and any limitations on scheduling of the tool. These summary sheets do not replace tool training or manuals, but instead are to be used for quick reference of important information.

6.5 *Equipment Problems or Damage*

All equipment problems should be reported immediately to PNF staff. In no case should a user attempt any repairs to the tool beyond what is explicitly allowed in the facility operating instructions for the tool. As with all things, if a user is uncertain how to proceed, they should check with staff before taking action. The equipment in the facility is very expensive and much of it is very delicate.

Considerable damage can be done at a great cost of both money and downtime by careless attempts to fix things.

EMERGENCY MANUAL OFF (EMO)

Most tools have EMO switches that will disable all power to the system, and should be used in emergencies. Using an EMO can be detrimental to your process, so users and staff 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 are not emergencies that warrant the use of an EMO.

6.6 Equipment Scheduling

Tool use is scheduled in one of two ways:

- 1) Using the web-based FOM system at, <http://fom.uchicago.edu>
- 2) When working in the PNF, you may also reserve an unscheduled tool using FOM on a first come/first served basis.

If a tool is listed on FOM, you must obtain permission from the supervisor of the tool in order to schedule use of the tool. This is typically accomplished by attending a training session.

Some tools are not scheduled using FOM because the cycle period is typically short and use of the tool is most efficient without users signing up. All tools in the PNF have an Equipment Manager (or EM), regardless of whether the tool is listed on FOM.

If you have problems with any tool, please inform the Equipment Manager/EM either by email, or direct communication (phone, etc).

6.7 Buddy System

For safety reasons, no one is allowed to work alone at the wet processing stations in Bay 6 after hours. Undergraduates are never allowed to work alone in the PNF or serve as a buddy for another undergrad. For users approved for extended hours PNF access, there may be occasions (such as a late night or over a long holiday weekend) when there are no other people working in the PNF. When you need access to the wet benches in Bay 6 outside of business hours, please coordinate your process schedule with another PNF user or staff such that you are not alone when using Bay 6 wet processing. Violators of this policy will suffer restrictions and possible banning from the PNF at the discretion of the PNF management. The buddy system policy is open to revision and proposals for changes are always accepted by the staff.

7 PNF Cleanroom Procedures and Protocols

Every time material is brought into the cleanroom, contamination is carried with it. One aspect of keeping the PNF clean is to minimize the amount of material brought into the facility. Only necessary materials should be brought into the PNF cleanroom.

Special ventilation equipment is installed and operated and we have implemented standard operating procedures to assure the level of cleanliness in the PNF. The PNF clean room is ISO class 5.

ISO 14644-1 cleanroom standards (partial list)

| Class | maximum particles/m ³ | | | | | | FED STD 209E equivalent |
|-------|----------------------------------|----------------------|----------------------|------------|-----------|---------|----------------------------|
| | ≥0.1 µm | ≥0.2 µm | ≥0.3 µm | ≥0.5 µm | ≥1 µm | ≥5 µm | |
| ISO 4 | 10,000 | 2,370 | 1,020 | 352 | 83 | 2.9 | Class 10 |
| ISO 5 | 100,000 | 23,700 | 10,200 | 3,520 | 832 | 29 | Class 100 |
| ISO 6 | 1.0×10 ⁶ | 237,000 | 102,000 | 35,200 | 8,320 | 293 | Class 1,000 |
| ISO 9 | 1.0×10 ⁹ | 2.37×10 ⁸ | 1.02×10 ⁸ | 35,200,000 | 8,320,000 | 293,000 | Room air |

7.1 PNF Apparel and Gloves**7.1.1 Proper Gowning Procedure**

The cleanroom suit consists of three parts: the hood, the suit or coverall, and booties. Proper gowning technique is important to ensure the cleanliness of the garments and the facility is maintained.

Before entering the cleanroom, users should make certain they meet the clothing requirements listed in section 5.4. Then, follow the gowning or donning procedure to enter the cleanroom:

- Wash and dry your hands (bathrooms are located in the NE corner, LL105/107).
- Clean your shoes using the automated shoe cleaner.
- Swipe to enter the pre-gowning area, LL179.
- Be sure to step on all tacky mats as you proceed through the cleanroom entrances.
- Hang or stow outerwear and other gear on the rack provided in the pre-gowning area.
- Put on a bouffant, assuring that all hair is completely contained under the bouffant (optional beard covers are available).
- Put on your first set of gloves.
- Put on disposable shoe covers.
- Enter the cleanroom gowning area through the automatic door.
- Place all items being taken into the cleanroom onto a designated shelf or bench
- Carefully slide the hood from the bag, touching only inside of the hood.
- Put the cleanroom hood on with the barcode on the inside. The hood is often packaged inside out so check it carefully. Snap the hood under the chin.
- Carefully slide the cleanroom suit or coverall from the bag touching only the inside.
- Put on the cleanroom suit, being careful not to drag the suit on the floor in the process. Tuck the bottom of the hood into the suit, zip it up, and snap the top snap.
- Put on the booties, 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.
- Put on goggles.
- Either remove donning gloves or put on second pair of gloves over first pair. Roll gloves over cuffs of coverall sleeves.

- Using the spray bottle, moisten a cleanroom wipe with the water/isopropanol solution and wipe down all the items being brought into the cleanroom.

Once in the cleanroom, the cleanroom suit should never be opened or unzipped except in cases of emergency. If something under the suit is needed, return to the Gowning room to open the suit and retrieve it. Anything that a user needs access to while in the cleanroom (i.e. smartphones, etc.) should be taken out while in the gowning room and wiped down.

When exiting the cleanroom, simply reverse the steps, placing the coverall, hood, and boots on a hanger, labeled with a number corresponding to a shelf. Continue to reuse this suit upon each entry.

- Remove boot covers, then discard top pair of gloves. If only one pair of gloves is worn, remove gloves last. Store booties downwind of coverall.
- Remove coverall and if it will be used again, carefully hang it on the rack provided.
- Remove eyewear.
- Remove hood: hang with other garments.
- Exit gowning room.
- Remove and Discard bouffant cap.
- Remove and discard shoe/boot covers.
- Remove and discard gloves.
- Wash your hands.