

Nanofabrication Cleanroom Safety Manual

Introduction

The Penn State Nanofabrication Cleanroom management team is committed to providing a safe working environment for its users. The goal of this manual is to provide information and guidance to the certified users of the cleanroom on how to conduct their research in a safe manner.

This document attempts to cover all acceptable operating and safety policies of the cleanroom including practices, policies and procedures as they relate to safety as well as details of equipment use, chemical and compressed gas safety. It is impossible, however, to define a policy for every conceivable situation. Users should use a common sense approach when working in the cleanroom. Safety is everyone's responsibility. Again, **it is each user's professional duty to be responsible for their own safety and the safety of others.** Users who fail to follow the policies outlined in this manual or fail to act in a professional, safe and responsible manner while conducting research in the cleanroom risk having their access to the cleanroom suspended or revoked.

NOTE: Users' suggestions and feedback on any aspect of the cleanroom, staff, operation, or equipment are welcome and highly encouraged. Please feel free to direct your suggestions to any of the cleanroom's technical staff, advisors, or faculty directors.

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General Information

Safety Training and Cleanroom Orientation

All PSU cleanroom users are required to read this safety manual and complete the Penn State University Lab Safety Training Program and a Nanofabrication cleanroom specific orientation in order to use the laboratory. The Lab Safety program provides an overview of general laboratory safety procedures, proper chemical use and disposal procedures, as well as general lab use and etiquette. Users can complete this training online at the website of the Penn State University Environmental Health and Safety Organization (EH&S) (<http://www.ehs.psu.edu/>) (Note: a Penn State Access Account ID or Friends of Penn State ID is required) or by attending a safety class provided by the Penn State Materials Research Institute (MRI) Safety representative. The Nanofabrication cleanroom orientation includes a lab walkthrough conducted by a MRI staff member during which important safety items and issues are identified for the users. The orientation also provides information on research ethics and societal impact.

Access

Access to the cleanroom is for certified users and technical staff only. In order to become a certified user of the cleanroom you must have completed items described in the previous paragraph. Upon completion of those items, certification is granted for one calendar year. At the end of each calendar year users are required to undergo safety recertification by completing the Penn State University Environmental Health and Safety Organization (EH&S) online refresher safety training course. (<http://www.ehs.psu.edu/>) If a user fails to complete recertification, cleanroom access will be suspended until recertification is completed.

PLEASE NOTE: access to the cleanroom in and of itself does not grant certified users the right to operate equipment. In order to operate equipment, certified users complete equipment training. Details on equipment training can be found in the [Equipment Use Safety](#) section of this document.

Research Instrument Management System (RIMS)

RIMS is the web-based software platform used for reserving equipment, tracking equipment use and lab time and billing in all user facilities overseen by the Office of the Vice President for Research (VPR) at Penn State University. The system was formerly

designated as the “Portal” (prior to 7/2010) and was developed in collaboration with a commercial vendor, Versatile, and customized for use by Penn State’s user facilities. In order to begin work in the cleanroom you must setup an account in RIMS. Details on how to obtain a RIMS account can be found on the MRI’s RIMS Launchpad page. (http://www.rims.psu.edu/faqs/getting_started.asp)

Hours of Operation/ Off Hours Use

The Penn State Nanofabrication clean room is open for use seven (7) days a week, twenty four (24) hours a day. If the cleanroom is closed for any reason, information concerning the reason for shut down and the estimated duration will be posted on the MRI’s RIMS Launchpad page (http://www.rims.psu.edu/faqs/getting_started.asp) as well as on monitors outside the cleanroom gowning area.

Although the cleanroom is open seven (7) days a week, twenty four (24) hours a day, it is only staffed Monday thru Friday from 8:00AM to 6:00PM. To ensure a safe working environment for our users we have implemented a “Buddy” policy in which users working between the hours of 6:00PM and 8:00AM must work with another certified user of the cleanroom. Details on the procedures of the “Buddy” policy can be found in the [Appendix D](#) of this document.

Cleanroom Protocol and Etiquette

The cleanroom is designed to meet the ISO class 100/1000 standard. In order to ensure the safety of the users and staff and in order to maintain the integrity of the cleanroom environment, users are expected to work in a professional manner. Professional conduct includes, but is not limited to, dressing in proper attire (including all pertinent personal protective equipment) at all times, responding to and following the direction of cleanroom staff and observing all rules and regulations concerning allowable materials and items in the cleanroom, chemical use and handling, access to restricted areas and equipment use. In addition, as a certified user of the cleanroom, you are required to report activities of other users that do not conform to rules and standards outlined below to the staff or management. Safety is the responsibility of everyone.

Proper Cleanroom Attire

Proper cleanroom attire includes gowning in full cleanroom suits including hairnets, hoods, body suits, shoe covers, boots, masks, safety glasses and gloves in

the proper sequence and location and wearing proper Personal Protective Equipment (PPE) where required. Details of proper gowning are found in [PPE Section](#) of this manual, in the Nanofabrication Cleanroom Laboratory Manual, on posters in the cleanroom gowning area and is also demonstrated during the Nanofabrication cleanroom Orientation session. Proper cleanroom attire also includes what is on your body **under** your cleanroom attire. The following rules apply:

- **Never wear make-up if you are working in the cleanroom!**
- **Never wear Sandals when working in the cleanroom.**
- **Never bring coats, hats, backpacks, canvas bags, etc. into the cleanroom. Users should store these items in their offices or the lockers outside the cleanroom.**
- **Never wear dirty clothes, particularly muddy boots or shoes, into the clean room. During the winter bring an extra pair of clean dry shoes to be worn the clean room.**
- **Never unzip a cleanroom gown to retrieve an item from an underlying garment pocket while in the cleanroom proper. Our cleanroom suits come equipped with an external pocket in which a phone or other cleanroom allowable item can be stored. The item must, of course, be wiped down in the gowning area prior to insertion into the pocket and cleanroom entry.**

***A SPECIAL NOTE CONCERNING SAFETY GLASSES:** Users, visitors and staff must wear safety glasses at all times when in the cleanroom. All safety glasses must comply with the requirements set forth in the American National Standards for Occupational and Education Eye and Face Protection ANSI Z87.1 approved. If you wear glasses you can wear them as long as they have shatter proof lenses and side shields. If you have you own safety glasses you may wear them in the cleanroom as well but they must be ANSI Z87.1 approved.*

Materials Restrictions and Procedures

In following good cleanroom practice; a general rule to live by is to **NEVER** bring anything into the cleanroom that is not absolutely necessary for the research you are conducting. Any item brought into the cleanroom must be cleanroom compatible and thoroughly cleaned / wiped down prior to entry. There is a wipe down station in the gowning area with proper cleaning materials and instructions. In addition the following specific restrictions apply:

- **Never bring pencils or erasers into the clean room.**
- **Never bring cardboard or other packing material into the cleanroom.**

- **Never bring books, newspapers, magazines, and other reading material into the cleanroom! Only clean room paper and cleanroom notebooks are allowed.**
- **Never bring food into the cleanroom.**

Restricted Access Areas

As a general rule all cleanroom chase areas, unless specifically labeled otherwise, are restricted to staff only. Users are prohibited from entering these areas. If a user has a need to be in a chase area, he/she must get permission from staff or be accompanied by staff into the area. The Nanofabrication cleanroom sub fab is also a restricted area and the same rules apply. In addition, the following specific restriction applies:

- **Except in cases of emergency, users, visitors and staff are not to open doors to exterior corridors for any reason while in the cleanroom.**

Surveillance Cameras

Surveillance cameras are located throughout the cleanroom in order to monitor user and staff actions. These cameras allow the staff to monitor the activities in the cleanroom from a remote location at all times. The cameras are essential for assessing cleanroom occupancy during an emergency and are also used in the enforcement of all safety and etiquette protocols, particularly in the off hours.

Eyewash and Safety Showers

Due to the hazardous nature of many of the chemicals used in the cleanroom, there are eyewash and safety showers located throughout the cleanroom and in the hallways just outside the cleanroom. The location and use of this equipment are explained during the cleanroom orientation. [Appendix C](#) of this document provides a map of the cleanroom that identifies the locations of all eyewash and safety showers.

Cleanroom Alarms / Evacuation/ Emergency Response

Due to the presence of hazardous materials and equipment in the cleanroom and its support space, (i.e. Hazardous chemicals, Hazardous gases, High Voltage Equipment, etc...) there are multiple systems installed that monitor safety. Each of these systems is equipped with visual and audible notification alarms including horns and strobe lights. If there is a fire or a release of a Hazardous Process Material (HPM) the monitoring systems will detect it and set off audible (horns) and visual (strobe) alarms in the cleanroom and sub-fab. Cleanroom users must be aware of these alarms and be able to identify them quickly and react accordingly. The following are a list of alarms users may encounter in the cleanroom:

Fire Detection Alarms

Fire alarms and Pull Stations are located throughout the cleanroom and the sub-fab. Their visual and audible indicators are a white flashing strobe and horn. In the event the fire alarms are activated, users should exit the cleanroom via the closest emergency exit (DO NOT STOP TO REMOVE YOUR CLEANROOM GOWN!). Once you have exited the cleanroom into the hallways, follow the appropriate building evacuation path indicated by wall signage to exit the building.

Toxic Gas Detection

Toxic gas sensors and strobes are located throughout the cleanroom and sub-fab. Their visual and audible indicators are a blue flashing strobe and horn. In the event the toxic gas alarms are activated users should exit the cleanroom via the closest emergency exit (DO NOT STOP TO REMOVE YOUR CLEANROOM GOWN!). Once you have exited the cleanroom into the hallways follow the appropriate evacuation path indicated by wall signage to exit the building.

The operation and location of the fire and toxic gas detection systems are covered in the Cleanroom Orientation walkthrough.

[Appendix A](#) & [Appendix B](#) of this document provides a map of the locations of the alarm systems as well as the evacuation paths for exiting the cleanroom and the building. Users are expected to review this information prior to using the Nanofabrication cleanroom.

[Appendix F](#) of this manual contains the University's Emergency Response Procedures to be used in case of an emergency.

Visitors

Visitor tours of the cleanroom can be arranged by contacting the Administrative Staff (Susie Sherlock: sjs10@psu.edu). Standard visitor tours provide only window access to the cleanroom. Special tours that include cleanroom entry are extremely limited and by special request only. Please note that all visitors who enter the cleanroom must be escorted by either a certified user or a member of the technical staff. Under no circumstances may a visitor be allowed to operate equipment, use chemicals, or be left unattended in the cleanroom.

Cleanroom Safety and Etiquette Enforcement

Safety is the top priority for all activities carried out within the cleanroom. There can be no compromises with regards to safety in completing a research project. The technical staff is charged with providing a safe cleanroom environment for all users to carry out their research and it is the responsibility of each user to see that the environment is utilized in a safe manner. In order to guide users, the MRI safety committee has developed general safety policies in conjunction with and guided by Penn State University's safety policies that must be followed by all users and staff. These policies have been devised based on state and federal laws, basic materials, chemical and process knowledge and common sense. In some cases, the policies were created in response to specific incidents by users of the cleanroom.

****ALL USERS AND STAFF ARE CHARGED WITH THE ENFORCEMENT OF THESE POLICIES****

If a user or a staff member observes another user or staff member in violation of clean room safety or etiquette policies or otherwise compromising his or her personal safety or the safety of others it is their responsibility to not only point it out to the user in violation but also to report it to another staff member or an MRI safety officer (observation of violations can also occur when staff regularly review video from lab surveillance cameras). At that point, the user in violation will be asked to leave the cleanroom and their access to the cleanroom will be temporarily revoked. The user in violation and the user's PI will then be notified by email and an internal review of the incident will be conducted by Nanofabrication Cleanroom Safety Committee. The committee member(s) will determine what actions will be taken in response to the safety violation. Users should be aware that suspensions from the clean room may be for a day, a period of several weeks, months, or permanently, depending on the severity of the violation and whether the user has previous violations. Please be aware that ***readmission to the clean room will be at the sole discretion of the committee.***

Ignorance of cleanroom safety policies, lack of common sense, language difficulties, carelessness and haste are not adequate excuses for unsafe behavior. Each user must remember that they are responsible for their own safety and the safety of others.

Safety Incident Reporting

All safety related incidents are required to be reported to the Penn State University Environmental Health and Safety Organization (EH&S). The reporting requirements for different types of incidents can be found on the PSU EH&S site (<http://www.ehs.psu.edu/>). If you have any questions regarding the reporting requirements, please contact one of the cleanrooms Technical staff immediately to get clarification.

Equipment Use and Safety

Introduction

Granted user access to the cleanroom does not in and of itself allow users to use equipment. Nanofabrication cleanroom safety policy requires that equipment in the cleanroom can only be operated by certified users who have completed the appropriate equipment training sessions. To ensure that equipment is used only by trained, certified users, interlocks have been added to every major piece of equipment in the cleanroom. These interlocks are controlled and managed through the RIMS software platform and allow use by only trained, certified users.

Equipment Training

The cleanroom technical staff is solely responsible for equipment training and has developed a comprehensive program. The purpose of the program is to ensure that all certified users of the cleanroom who require equipment training receive information and hands on training that provide them a comprehensive understanding of the operation and capabilities of the tools they will be utilizing.

The Equipment Training Program consists of a minimum of three training sessions. Typically, the first session provides general background tool information and a demonstration of tool operation by the responsible staff member. The second and third sessions are one-on-one tool use sessions between user and staff usually utilizing the user actual sample during the training. Certification is granted by the staff at that point if they are satisfied that the user can competently operate the tool. If this does not occur, more sessions are required. Certified trained user information is then entered into the RIMS database for the tool and the user is free to reserve the tool for use. Users can find additional detailed information on the Equipment Training Program in [Appendix E](#) of this document.

NOTE: Equipment Training Schedules can be found on the RIMS Splash page. If the tool you are interested in being trained on is not found on this page, please contact the administrative staff.

Equipment Operation

There are operational manuals for each piece of equipment detailing the operational procedures and capabilities of each. The manuals are referred to during the equipment training sessions and are kept at the tools for reference.

For some of the equipment, the technical staff have written simplified instructions to cover the basic operational steps and procedures. The technical staff provides the user with a copy of the simplified instructions during the equipment training sessions if applicable. Users should maintain these instructions for future reference.

NOTE: Equipment should only be used for its intended purpose. If you are not sure if the tool can provide the results you require or can be used with the materials you have on your substrate, please ask the appropriate staff member for guidance.

Equipment Issues

Cleanroom safety policy requires that users notify the technical staff of any equipment damage or malfunctions.

Users should never try to fix an equipment problem unless instructed to do so by the technical staff. The purpose of this policy is to prevent possible injury to the users and to prevent damage or further damage to the equipment which could result in extended downtime and expense.

Chemical Use and Safety

Introduction

A wide variety of chemicals are used for device processing in the cleanroom. Most of these chemicals are dangerous substances by nature and/or are hazardous when heated or mixed with other chemicals. Without adequate knowledge of the hazards or in the absence of appropriate precautionary measures, accidents can occur. The experience of the staff and management of the cleanroom indicates that wet chemical spills and exposures are the source of the majority of the safety incidents experienced each year. In light of this experience, the cleanroom has developed and implemented conservative chemical use procedures and policies. These policies may seem restrictive and unnecessary to many users, but every user should realize that they are in place to maximize the safety of all users and staff. In general, safe chemical use includes minimizing exposure to chemicals, proper training, understanding chemical hazards, proper labeling, proper storage and segregation, and proper transport. Users should ask themselves and find answers to a number of key questions BEFORE they use chemicals in the cleanroom. The key questions are:

1. Do I really need to use this chemical in my process or is there some less hazardous material that can be substituted?
2. Do I understand the hazards presented by the chemical or chemicals I intend to use?
3. Do I know the procedures and requirements for handling the chemical particularly with regards to personal protective equipment (PPE) that must be worn?
4. In case of a spill or exposure do I know where all the chemical safety equipment is located in the cleanroom and how to use it?
5. Do I know how and where to properly store unused quantities of the chemical and how to transport it?
6. Do I know how to properly and safely dispose of the used chemical after use?

In order to help users find answers to these questions, information is provided below in the cleanroom chemical use policies.

Specific procedural details are included in the manuals for individual equipment. The information below is intended to supplement the information that users acquire from the required training outlined in the introduction to this manual. All users, including the

cleanroom technical staff members must follow these policies and procedures as well as all Penn State University Chemical Use Policies and Procedures.

- 1. Do I really need to use this chemical in my process or is there some less hazardous material that can be substituted? If not, do I know procedures for getting the chemical and bringing it into the cleanroom?*

The best way to try to determine if a particular chemical is required in your process is to consult with your advisor, group members, the technical staff and the MRI Safety Coordinator. If they are unable to provide answers; please contact the manufacturer directly for input.

Chemical Supplies

Users are not allowed to bring their own chemical supplies into the cleanroom without prior approval from the MRI Safety Officer. If chemicals are brought in with the approval of the MRI Safety Officer, they must be in the original container complete with labeling. Once in the cleanroom, the chemicals are under control of the staff. If not stored in the chemical cabinets in the cleanroom, the user must request the chemical from the staff when it is to be used. Users are not allowed to remove chemicals (including those furnished by the users) from the cleanroom.

The cleanroom stocks and supplies all the common chemicals used in the cleanroom. The cleanroom will not distribute these chemicals to other labs or groups in the building or on campus.

The chemical supplies are kept in an area where only the appropriate MRI technical staff has access.

2. Do I understand the hazards presented by the chemical or chemicals I intend to use?

The first and primary source of information on any chemical is the Materials Safety Data Sheet provided or available from the manufacturer. In addition to this, the technical staff is very knowledgeable, and may be able to provide additional information. **When in doubt, ASK.**

Material Safety Data Sheet (MSDS)

The MSDS sheet provides basic information for a given material or chemical product. It contains information on the properties and potential hazards associated with a given material as well as its compatibility with other chemicals. It also provides information on how to safely handle the material, and what to do if you are accidentally exposed to the material.

OSHA requires the **Material Safety Data Sheet (MSDS)** for every material that is used in the cleanroom be provided and available in paper form in the cleanroom. Before working with any material, whether it is a gas, liquid or a solid, in the cleanroom users must review the MSDS information so that they are aware of the potential hazards associated with using the material as well as the proper exposure responses.

Note: There is an MSDS station in the gowning area of the cleanroom. The technical staff maintains MSDS information on all materials used in the cleanroom in a binder at that location. If a chemical is not currently used, MSDS sheets are available from the manufacturer and can also be found by doing an online search.

3. *Do I know the procedures and requirements for handling the chemical particularly with regards to personal protective equipment (PPE) that must be worn?*

Personal Protective Equipment (PPE)

A Personnel Protective Equipment (PPE) Hazard Assessment of the cleanroom was completed by the MRI Safety Officer. The assessment results require that some or all of the following PPE be used when working with chemicals in the cleanroom Wet Chemical Bay (N-109R) and is dependent on particular chemical and bench use:

- Chemical resistant gloves.
- Sleeved aprons are to be worn when working with any chemical in the wet bench bay
- Goggles
 - Face shields are to be worn when pouring chemicals

Detailed information on PPE requirements and use procedures for each bench in the bay and the equipment itself can be found at the PPE station just outside the Wet Chemical Bay or in the manual for a specific bench. All required PPE must be donned prior to entering the Wet Chemical Bay. If the required PPE is not available at the PPE station for use, please find a staff member and request the equipment. Do not enter the wet chemical bay without it. Floor demarcations indicate the area in which users must have required PPE on. The PPE and the PPE station(s) are supplied and maintained by the staff.

PLEASE NOTE: Failure to wear the proper PPE required for a particular bench and/or chemical is considered a safety violation and will result in immediate use privilege suspension. Repeated violation can result in the permanent suspension of user privileges for the Wet Chemical Area. Also, it is critical to note that while the user may be using comparatively benign chemicals, their neighbor may be using more hazardous materials.

Chemical Transfer, Secondary Container Labeling and Cleaning

In most instances, wet chemical use in the cleanroom requires that the chemical be transferred from its original container into a secondary container in which the work will actually be done. Specific procedures concerning chemical use are found in each of the bench manuals.

NOTE: All secondary containers must be labeled. The full chemical name, concentration, the user name, date and must be on the label. Secondary containers, in general, are not to be left unattended in off hours. Procedures for leaving chemicals in the benches for an extended period of time are specific to the benches and are found in the specific bench manual.

4. In case of a spill or exposure do I know where all the chemical safety equipment is located in the cleanroom and how to use it?

During the cleanroom orientation walkthrough, the locations of all safety equipment will be pointed out. All users should be aware that even though they may not be using especially hazardous chemicals, it is possible to become exposed to hazardous chemicals, due to their presence in the cleanroom. All users need to be alert and careful while working in the cleanroom, and must be aware of safety procedures.

Chemical Spills

Accidental chemical spills no matter the volume, must be reported to the staff immediately. Any material used in the clean up a chemical spill must also be treated as hazardous waste and disposed of accordingly. Refer to [Appendix F](#) for the details on proper chemical spill cleanup.

If a user comes into contact with a hazardous chemical, **Call for help immediately.**

- a. If the chemical comes into contact with the eye, the eye wash should be used. The user will need to hold open their eyes, using their thumb and fingers, and rinse for several minutes.
- b. If the chemical reaches other parts of the body, remove contaminated clothing, and/or rinse with a lot of water using the eye wash, a sink, or the safety shower. In such a situation, the user's health is more important than modesty.

USERS SHOULD IMMEDIATELY NOTIFY A STAFF MEMBER IF A CHEMICAL SPILL OCCURS!

5. Do I know how and where to properly store unused quantities of the chemical and how to transport it?

Chemical Storage

There are chemical storage cabinets, separated by chemical classification, in the wet chemical bay where the “**in-use**” chemicals and chemical waste are located. Each of the cabinets is designated for a different class of chemical and is clearly identified on the outside of the cabinet.

The staff will stock these cabinets every morning and afternoon. If during the day a user finds we are out of a particular chemical they need to contact a staff member and have them replenish the chemical.

Users must not open a new bottle until the old one is empty. When you empty a chemical bottle, **you must thoroughly wash and rinse it.** (Rinse water may be safely disposed down the drain). The cleanroom uses these empty chemical bottles for waste collection.

We have very limited chemical storage so users should not store user specific chemicals in the cabinets without receiving staff approval first.

6. Do I know how to properly and safely dispose of the used chemical after use?

Chemical Waste

Chemical waste generated in the cleanroom must be stored in a properly labeled container and then placed in the proper waste cabinets. Pre-Printed chemical labels are provided by the technical staff for most commonly used chemicals. These labels have all the chemicals and chemical mixtures that are compatible with each other.

The Technical staff has tried to consolidate as many chemicals as possible to minimize the number of waste containers generated in the cleanroom. However some chemicals / chemical mixtures used in the cleanroom should not be mixed with other any other chemical and therefore do not have pre-printed labels. In lieu of pre-printed labels the Technical staff provides blank waste labels. The users are responsible for filling these labels out with all the correct chemical information for the waste being discarded in the waste container.

Prior to disposing of your chemical into chemical waste bottle users should adhere to the following guidelines:

- Place the waste receptacle into a deepsink, so that if a spill occurs, it will be contained.
- Always use a funnel when pouring a chemical solution into a waste bottle. Users should hold pour with two hands.
- Do not overfill waste bottles. Bottles should only be filled approximately $\frac{3}{4}$ of the way to the top. This is to allow for thermal expansion of the chemicals. If a bottle is overfilled it can lead to overflow or rupture.
Do not over tighten the cap on a waste bottle!!!
- Only use vented caps to seal chemical waste bottles. The caps are located just outside the Wet Chemical Bay area. If none are available please contact the Technical staff and they will replenish the inventory.
- Empty Chemical waste bottles are stored on racks just outside the Wet Chemical Bay area. The rack shelf will be prominently labeled as “Chemical Waste Bottles” These waste bottles are recycled plastic chemical bottles. Prior to pouring any chemical into a waste bottle users should rinse the bottles a minimum of 3 times.
Never assume the empty chemical bottle has been properly rinsed unless you have done it yourself!!!
- Always properly label the waste bottle prior to use. Preprinted and blank Chemical waste labels are located in the wet chemical bay and are to be placed on the EMPTY chemical waste bottle!
- **Chemical waste should never be intentionally poured down the drain!**
- **Users should never modify an existing pre-made waste label!** If a pre-printed label for your chemical mixtures is not available then use a blank chemical waste label to create one. When filling out the blank label you must fill out all the information (Chemical Name, Percent Composition if a Mixture, User Name, and Date) on the label.
- **Chlorinated solvents** (e.g. Methylene Chloride and Chlorobenzene) do not rinse well from bottles and other glassware. **These items must be rinsed in isopropyl alcohol first**, followed by DI water, to remove any residue. **The empty bottles for these chemicals should never be used as waste bottles.**

- **HF is only to be used and disposed of in the plastic labware and chemical waste bottles. This is due to the fact that HF etches glass (SiO₂) very well!**
- **It is essential that solvents and acids be kept separate.**

Chemical Waste bottles should always be placed in the approved chemical waste cabinet. If the waste cabinet is full please contact a staff member to assist you. They will dispose of excess containers.

Chemical Waste Satellite Accumulation Area

The Nanofabrication cleanroom has a satellite accumulation area in the sub-fab where all chemical waste material is stored prior to being sent out for processing. All containers located in the satellite accumulation area must have the appropriate red waste tag. These red waste tags are supplied by EH&S and must be properly filled out. The MRI Technical staff performs weekly required inspections of this area. The Satellite accumulation area is a restricted access area, accessed by authorized MRI Technical staff only.

Compressed Gas Safety

Introduction

Compressed gases and their containers (cylinders) are used in many Nanofabrication cleanroom processes and instruments. Compressed gases and cylinders can expose users to both chemical and physical hazards. Gases contained within compressed gas cylinders can be toxic, flammable, oxidizing, corrosive, inert, or some combination thereof. In the event of a leak, inert gases can quickly displace air in a large area creating an oxygen-deficient atmosphere, toxic gases can create poison atmospheres, and flammable or reactive gases can result in fire and exploding cylinders. Compressed gas can also be injected into the body through the skin if the gas is blown against the skin with sufficient pressure. In addition to the hazards presented by the gases themselves, there are hazards from the pressure of the gas and the physical weight of the cylinder. A gas cylinder falling over can break chemical containers and crush feet. The cylinder can itself become a high

energy projectile if the cylinder valve is broken off. Appropriate care in the handling and storage of compressed gas cylinders is essential.

Hazardous and Non-Hazardous Gases

Many highly toxic and corrosive gases are used in the equipment located in the Nanofabrication cleanroom. These gases are stored in the facilities sub-fab and are piped to the appropriate end use equipment. Only Authorized MRI staff and the appropriate EH&S representatives who have been trained in the proper safety protocols for the handling of compressed gas cylinders are allowed to handle gas cylinders for the cleanroom.

Compressed Gas Storage

All Nanofabrication cleanroom compressed gas cylinders not in use are stored in the designated chemical storage cage located at the Shipping and Receiving area of the Millennium Science Complex (MSC) building. This MSC storage area is posted with the names of all the gases being stored.

The cylinders stored in this area must meet the following criteria:

- Cylinders must be properly secured in an upright position with the proper valve protection caps in place.
- Full and Empty Cylinders must be stored separately and clearly marked.
- All cylinders must be secured to a solid support using the proper cylinder clamps and chains.
- Flammable materials must be kept a minimum of 20 feet from an oxidizers
- Oxygen cylinders are to be kept free from oil or grease to prevent the possibility of explosion.

Transportation of Compressed Gas Cylinders

All compressed gas cylinders used for the cleanroom are to be transported to the cleanroom sub-fab via the Hazardous Process Material Tunnel located in the Basement of the MSC building. During the transport of the cylinders between the sub-fab and the MSC gas storage lockers the following criteria must be followed:

- All cylinders (empty or full) must have the proper valve protection cap in place and properly secured.

- Cylinders may never be transported with a regulator attached.
- All cylinders will be transported using the proper sized gas cart for the cylinder being transferred. Any and all safety fasteners will also be in place and properly secured.

Compressed Gas Delivery

The Nanofabrication cleanroom uses a gas distribution system for the delivery of compressed gases from the sub-fab to the appropriate equipment above. The gas distribution system is designed to deliver both Hazardous Process Materials (HPM) and Non-Hazardous Process materials to the cleanroom equipment.

Any cylinder that contains a gas classified as an HPM is located in a special HPM room in the sub-fab to minimize any damage caused by a catastrophic release of the HPM gas. All gases located in the HPM room are housed in automated gas cabinets designated for the delivery of a specific HPM material and monitored by a Toxic Gas Monitoring System (see details below).

The Non HPM materials are located in cylinders outside the HPM room in the sub-fab and may or may not be housed in a gas cabinet depending on the classification and hazards associated with the gas.

All gas cylinders connected to a gas delivery manifold and not housed in a gas cabinet are changed manually. Special procedures followed by trained staff only must be followed when switching out these compressed gas cylinders.

The following criteria for the delivery of all compressed gasses in the gas distribution system must meet the following criteria:


- All lines installed as part of the gas distribution system are to be made of stainless steel.
- All lines are to be clearly marked as to what gas they are delivering.
- The proper regulators are always to be used.
- Any additional gas added to the gas distribution system will have the appropriate gas sensors added to the Toxic gas monitoring system.


Toxic Gas Monitoring System

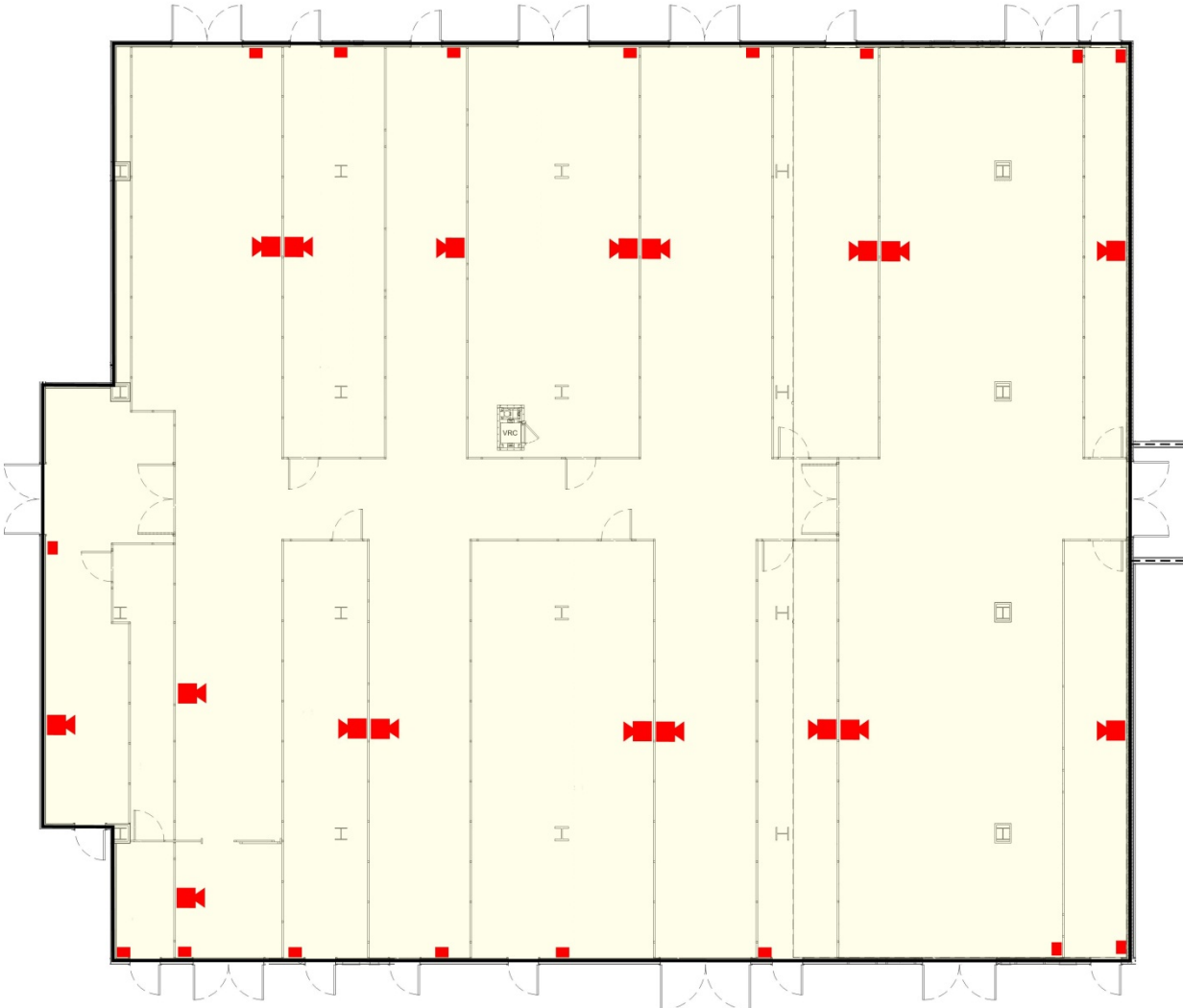
Due to the dangers associated with several of the gases used in the cleanroom, a Toxic Gas Monitoring System is integrated into the cleanroom gas distribution system. The system has detection points in the sub-fab and in the cleanroom space at critical delivery points. This system also contains additional detectors (i.e. Low O₂ sensor, High Explosive Level sensors, etc.) to ensure the safety of all users of the cleanroom and staff. The TGMS is maintained by the Nanofabrication staff and the detection signals and alarms are part of and monitored by the Building Management system.

APPENDIX

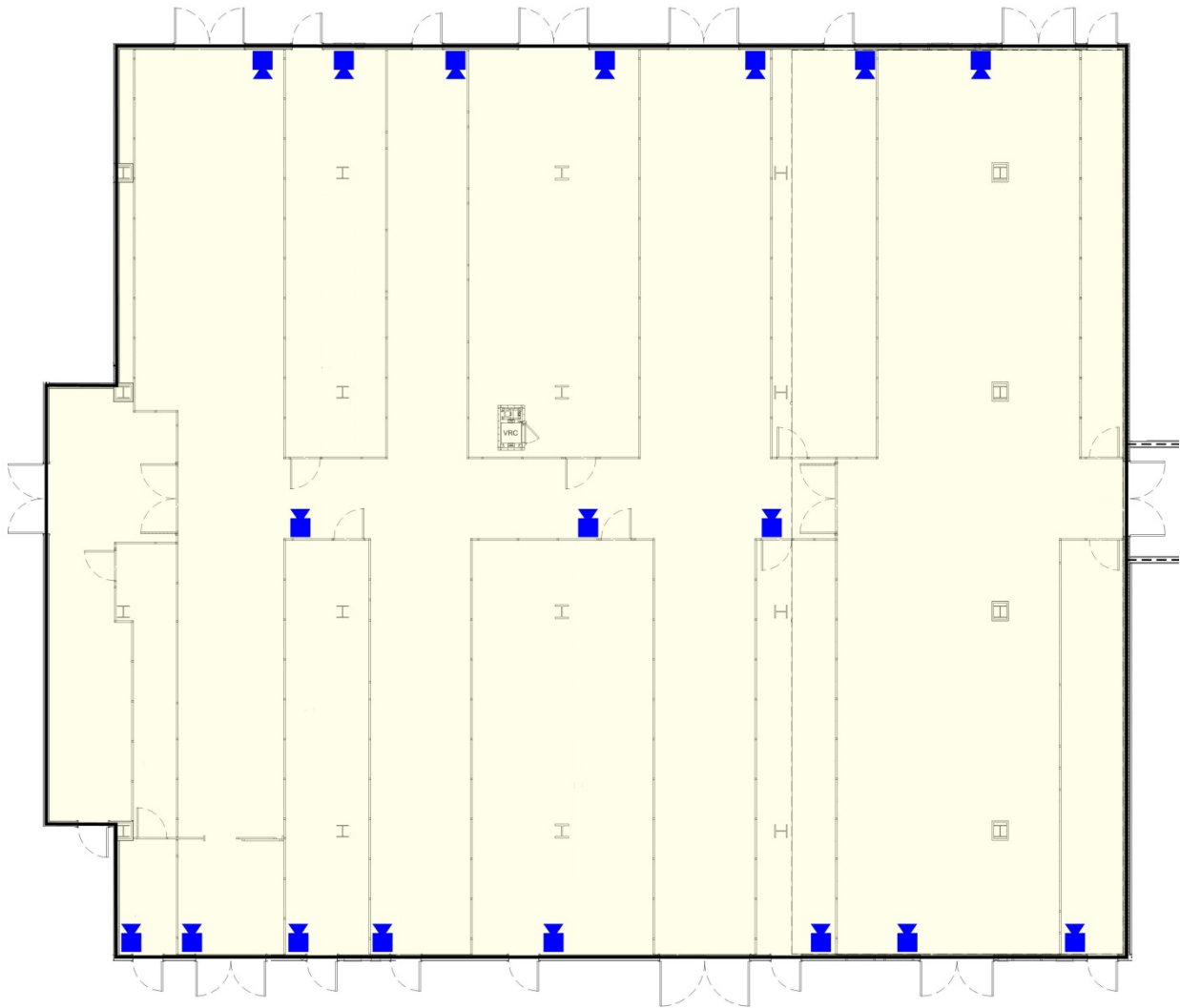
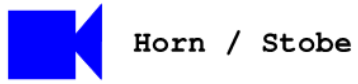
Appendix A: Fire Alarm Map

 Pull Station


 Horn / Strobe



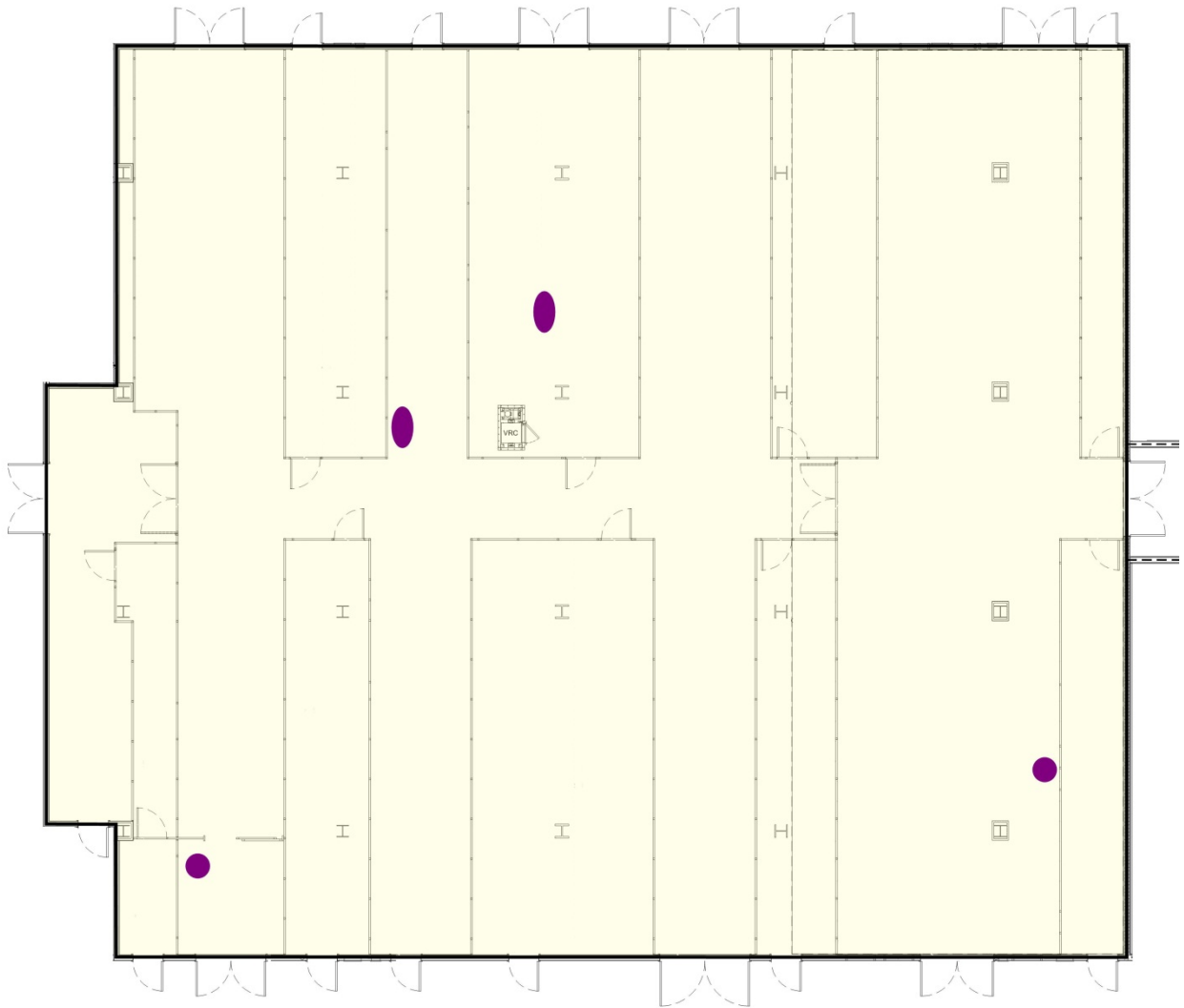
Appendix B: Toxic Gas Monitoring Alarm Map



Appendix C: Safety Eye Wash and Shower Map

 Eye Wash

 Eye Wash and Shower



Appendix D: Buddy Policy

In order to meet the requirements of the Buddy Policy certified cleanroom users who are working outside the normal business hours of 8AM-6PM must identify another **certified user** of the cleanroom who will be responsible for checking in on the user working in the cleanroom. That second certified user is required to check on their “Buddy” every 15 minutes to ensure they are safe or to call for assistance if there is an emergency.

Users and their Buddies must sign into the logbook after normal working hours (between 6PM and 8AM weekdays, and all day on weekends and holidays).

An additional requirement of our buddy program is that when a certified user is working in the wet chemical bay, their “**buddy**” must also be **in the clean room, aware** of their situation, and **close enough** to be of assistance in case of an accident. The individual acting as your buddy does not need to be at your side constantly, just available and aware.

Use of the **standard lithography chemicals (i.e. resists, developers, and solvent based resist strippers)** in the Lithography area without a buddy present inside the clean room is acceptable.

Appendix E: Equipment Training

The following is a description of how each session in our equipment training program is setup as well as any additional requirements for users.

Session One (scheduled through the Administrative Staff)

This training session offers a General Overview of the equipment. This session is instructed by one of the Technical staff responsible for the operation and oversight of the equipment. The session will cover the equipment capabilities and demonstrate the operation. To ensure users get the most out of these sessions the number of attendees will be limited to 3-5 certified users depending on the equipment.

The Session One trainings are offered on a weekly basis for most of the equipment in the cleanroom. There are a couple of exceptions of this due to the complexity of the equipment. The information on the Equipment Training can be found on the RIMS splash page or by contacting the Administrative Staff.

Session Two (scheduled directly with the Technical staff in charge of the equipment)

The second training sessions users will schedule directly with the Technical staff responsible for the equipment operation and oversight. This is a one on one training session between the user and the technical staff. In this session the certified user will operate the tool under the guidance of the Process Engineer. Users must bring a sample for their research to the training session for processing. This allows the Technical staff an opportunity to better understand what the user is trying to accomplish and to provide any necessary feedback on how to process their sample.

Session Three (scheduled directly with the Technical staff in charge of the equipment)

This session is again a one on one training session with the Technical staff responsible for the equipment operation and oversight. This is considered the “Competence Training Session”. The user will operate the tool with limited to no guidance from the Technical staff. The Technical staff will ask questions regarding operation and fundamental techniques to ensure the user fully understands the operation of the tool. At the end of the session if the Technical staff in charge of the tool deems the user competent to operate the tool without further assistance the user will be added to the list of certified users of the equipment.

If for any reason the Technical staff does not feel comfortable allowing the user to operate the tool independently then another training session will be scheduled. This will occur until the Technical staff feel the user has an adequate grasp on the operation of the equipment.

Users must bring also bring a sample related to their research for the training session as well as any results from the previously processed sample. Again this is to allow the Technical staff an opportunity to better understand guide the users and ensure they are on the correct path and that the tool is operating properly.

Most equipment trainings are held on a regular weekly schedule. The training schedule is available on RIMS in the "Message of the Day." Please sign up for training at least 4 business days prior to scheduled session. Training sessions will be cancelled if there are no attendees scheduled 4 days in advance.

Appendix F: Emergency Response Procedures

Police Services maintains the University's Emergency Response Plan and an Operation Plan for emergencies. The Emergency Response Plan formalizes responses to all classes of emergencies, from small events to catastrophes. In emergency situations, the role of University Police (UP) is to investigate the situation, provide site security, implement the emergency plan, and establish communications. EHS will advise and assist with hazardous-material spill control and cleanup. When the ability to respond adequately to an emergency is beyond the capability of University personnel, UP will call the local fire department or local hazardous materials response team.

For any Life threatening emergency call **911** immediately!

If you have a chemical, biological, or radiological incident that **DOES NOT** pose a life-threatening emergency you should:

- Call (814) 865-6391 (EH&S) Monday - Friday, 8 AM - 5 PM,
- Call (814) 863-1111 (University Police) on holidays or after normal working hours (5PM-8AM).

Fire

In case of a fire evacuate the cleanroom immediately and pull one of the fire alarms on the way out. Once out of the cleanroom users should follow the designated building evacuation routes. The building evacuation routes can be found on plaques in the hallways throughout the building. Users should familiarize themselves with these routes on a regular basis. Once emergency personnel have arrived on scene the user who initiated the alarm should provide the following information to the emergency responders:

- Name and title of person reporting incident
- Date, time and location of incident
- Phone number where the reporting person can be reached
- A brief description of incident

Chemical Spill / Gas Release

Users are to report all chemicals spills to EH&S that meet the following requirements:

- All chemical exposures or explosions requiring medical attention must be immediately reported to EHS after emergency procedures have been implemented.
- All spills/releases that result in bodily injury, enter surface water, are highly hazardous, or larger than 1 gallon must be reported to EHS immediately after emergency procedures have been taken. This includes highly hazardous materials chemicals such as hydrofluoric acid, chlorine gas, bromine, sulfuric acid, etc. If you are not sure, call EHS. For spills to paved surfaces or floors that have been cleaned-up, please report within 24 hours.

Users should follow the emergency procedures listed below in case of a chemical spill / gas release requiring emergency personnel to respond:

- Cease All activities
- Evacuate the immediate spill / release area
- Call 911
- Seek immediate medical attention, if necessary
- Keep people outside the spill area until the appropriate emergency responders determine that the area is safe for human occupancy.

The following information is to be provided to EHS emergency responders initially, and then followed up in writing within 48 hours:

- Name and title of person reporting incident
- Date, time and location of incident
- Phone number where the person reporting the incident can be reached
- Brief description of the incident
- Extent of contamination of land, water, or air, if known (e.g., bodies of water)

Small spills are to be cleaned-up by the facilities technical staff. EHS will provide technical advice if requested. Any absorbent materials used to clean up the chemical spill are to be disposed through the Chemical Waste Management Program. The following procedures should be followed when cleaning up a small chemical spill:

- Spills should be neutralized if possible using the appropriate chemical neutralization solution.
- Use a chemical absorbent material to cover the spill area in order to minimize the affected area.
- Collect all solid waste materials in a chemical waste containment bag (located in the chemical spill cabinet / cart)
- Properly label the bag with the materials generated in the cleanup.
- Contact a Technical staff member so they can submit a pickup request to EH&S

Medical Emergency

Medical emergencies such as chemical burns, inhalation injuries, falls, heart attacks, etc. require you to call **911** immediately!

Appendix G: Chemical Waste Labels

The following are examples of the chemical waste labels used in the cleanroom.

Chemical WASTE			
Standard Clean 2 (SC2, RCA 2) Waste Only			
Only these chemicals may be <u>COMBINED</u> as <u>WASTE</u> in this container:			
<u>Ingredients</u>	<u>Ratio</u>	<u>CAS #</u>	Do not add any other chemicals to this container
Hydrochloric Acid	1	7647-01-0	
Hydrogen Peroxide	1	7722-84-1	
De-Ionized Water	5	7732-18-5	
Waste Bottle Made By _____ Date Made _____			

Chemical WASTE			
Standard Clean 1 (SC1, RCA 1) Waste Only			
Only these chemicals may be <u>COMBINED</u> as <u>WASTE</u> in this container:			
<u>Ingredients</u>	<u>Ratio</u>	<u>CAS #</u>	Do not add any other chemicals to this container
Ammonium Hydroxide	1	1336-21-6	
Hydrogen Peroxide	1	7722-84-1	
De-Ionized Water	6	7732-18-5	
Waste Bottle Made By _____ Date Made _____			

Chemical WASTE - NANOSTRIP ONLY			
DO NOT ADD Sulfuric Acid or Hydrogen Peroxide			
<u>Ingredients</u>	<u>% by weight</u>	<u>CAS #</u>	Do not add any other chemicals to this container
Sulfuric Acid	90	7664-93-9	
Peroxymonosulfuric Acid	5	7722-86-3	
Hydrogen Peroxide	<1	7722-84-1	
Waste Bottle Made By _____ Date Made _____			

CHEMICAL WASTE

Please fill out the names of the chemicals in this waste bottle

Full Chemical Name	% of each chemical in bottle	If this waste is a chemical MIXTURE, please list all the chemicals and their percentages. Do not add any other chemicals to this container

Waste Bottle Made By _____ **Date Made** _____

Appendix H: Personal Protective Equipment