Notre Dame Nanofabrication Facility

Laboratory Operations & Safety Procedures Manual

Department of Electrical Engineering
University of Notre Dame

This manual is thought to be complete at the time of its writing and to accurately represent the operational policies of NDNF and the dangers involved in using NDNF facilities. Comments and suggestions regarding the contents of this manual should be directed to: Michael Thomas at Michael.D.Thomas.20@nd.edu.

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The NLOC is organized to promote increased safety in NDNF operations. They review equipment installations and procedures and recommend changes to the management.

A basic policy of the University of Notre Dame is to provide a safe working environment for its students and employees. A commitment to safety is especially important in university laboratories where many potential safety hazards exist. To achieve effective laboratory safety, the following guidelines and policies in this manual have been established.

NDNF Safety Policy: The Staff and Management of the NDNF have implemented all reasonable measures to ensure that the laboratory provides a clean and safe working environment. 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. Adherence to these safety recommendations will reduce laboratory accidents, spills and fires.

Users violating the operating and safety rules of the facility or endangering the safety of themselves or other users will be denied further access to the laboratory at the sole discretion of the management.

The NLOC Management

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EMERGENCY TELEPHONE NUMBERS

EMERGENCY…… 911

Notre Dame Fire Department (non emergency)**……. 1- 6200**

Campus Security Number ……..…….…. 1- 5555
This number is open 24 hours.

Risk Management and Safety Office ……...1-5037

8:00 AM to 5:00 PM
- Chemical Waste Pickup
- Chemical Spill Response
- Chemical Safety Information

Memorial Hospital 284-7459

St. Joseph Medical Center …….. 237-7264

Poison Control Center ……1-800-222-1222

University Health Services ……1-7497/1-7567

Safety in the Notre Dame Nanofabrication Laboratory

Welcome to the Notre Dame Nanofabrication Laboratory. Admittance to this facility is a privilege and not a right. Safety is the most important aspect of using the lab! You, as a user, must do everything possible to ensure your own safety as well as that of those around you. This manual will give the basic safety rules and guidelines that will help ensure that your work is as productive and safe as possible.

Safety is an overriding concern in all NDNF laboratory activities. All operations must be undertaken with the safety of both the individual user and other users as the primary consideration. In fact, operating safely is more important than getting your project done. As a general rule, anyone who violates any safety rule or otherwise compromises his or her personal safety or the safety of others will be denied access to the laboratory. These suspensions will be determined by the lab committee and may include permanent suspension. Ignorance of the rules, fatigue, language difficulties, carelessness, and haste are not acceptable excuses for unsafe behavior. For graduate students, violations could mean the end of your dissertation research. For outside users, it could mean the end of your project. Our policy is that users will be formally warned on the first minor infraction. A suspension is imposed upon the second minor infraction. Major infractions will result in immediate suspension. Readmission to the laboratory will be at the sole discretion of the laboratory management.

We wish to keep the laboratory an informal and friendly place to work. The staff wishes neither to make nor enforce rules unnecessarily. 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. In many cases, rules have been created in response to specific incidents of chemical misuse by users. In addition, a large volume of state and federal law covers chemical use in the workplace and disposal of waste. In spite of rules and staff supervision, primary responsibility for safety rests with the individual user. A responsible, considerate user with an understanding of basic chemistry and common sense will have little trouble with our chemical rules or chemical safety.

A majority of problems, violations, and equipment damage in the laboratory are the result of haste. Graduate students are under a lot of pressure. There is only so much time and much to do. However, you can waste your samples, waste time and money, get poor results, break things, and endanger yourself and others by being careless. Carelessness in the lab simply will not be tolerated.

Your safety in the laboratory is determined not only by your actions but also by the actions of those around you. Since the staff is in the laboratory only a fraction of the time the facility is open, the users are often in the best position to observe the behavior of others. Thus, if you observe someone else in the lab working in an unsafe manner, it is your responsibility to first bring it to his or her attention, and then if necessary, bring it to the attention of the laboratory manager, laboratory director, or a faculty member. The access of everyone to the facility depends on maintaining a safe working environment. A series of thoughtless violations or a single serious personal injury could result in closing of the laboratory for weeks. We hope that

peer pressure will result in conformance to safety standards where direct staff observation is not possible.

Potential dangers exist in many forms. For example, the laboratory is filled with sophisticated equipment employing chemicals that are dangerous on several levels either by themselves or in combinations. Also, compressed gases and high voltages are used in nearly every system.

Dangers in the facility fall into several categories:

Hazardous chemicals
Hazardous gases
Chemical fumes
Burns from hot plates or ovens
Burns from cryogenic liquids
Electrical
Compressed gases
Physical injuries (cuts, injuries from explosions, etc.)

The following general guidelines form the foundation of the safety rules

Hours of Operation

The laboratory is in operation 24 hours a day, 7 days a week. It is open only to qualified users who possess a keycard to access the laboratory. New users may be restricted from 8 to 5 Monday through Friday.

Badges and Keycard Access

The keycard is your authorization to enter the facility. The keycard is essentially your proof that you have received the required orientation and safety training. Keycards are issued for the sole use of a single person. Loaning your keycard to anyone else is strictly forbidden. Sharing of keycards or permitting unauthorized access to the facility is prohibited. The initial keycard issued is at no charge to you. However, if you break or lose your electronic keycard, there will be a $5 keycard replacement fee. Non-resident users will receive keycards for temporary use, and must be returned at the end of each visit. Persons without keycards specifically issued to them are not allowed to work in the facility.

Key Card Access ID Badges

a) Will have your picture, name, advisor's name, dept., and an RF ID tag that will be issued and worn at all times while inside the lab.
b) All users are responsible for the security and safety of their own badge.
c) Do not use anyone else's badge or allow your badge to be used by others.
d) Entry and exit to the lab will be through Room 247 using the keycard for normal routine use.

Visitors

No one may enter the facility without approval from laboratory management or faculty. Consequently, all guests or visitors must be approved for entry into the cleanroom by a member of the NLOC--in general, users may not bring friends, family, colleagues or others into the laboratory without the express permission of lab management. Any person escorting guests or visitors into the laboratory is directly responsible for their actions and their safety when touring the facility. The escort must be a registered user of the lab and have signed the lab "Safety Manual Agreement". A "guest" or "visitor" is anyone without a permanent keycard specifically issued to him or her. A "guest" is anyone coming into the lab for a tour or as a courtesy to show them our lab. These people will be issued temporary "guest" badges that have no RFID tag on the badge and as such do not have to log in or out of the lab. A "visitor" is someone who has access to the lab and will be issued a temporary "Visitor" badge with an RFID tag and as such must log in and out of the lab. A visitor badge will be issued for a period up to about 30 days. For longer periods the person will be issued a picture ID badge for entrance into the lab. Visitors using the lab must sign the lab "Safety Manual Agreement".

Group tours are a considerable disruption of the facility operation. Please make every effort to schedule them in advance with the Laboratory Manager.

Short and Simple Laboratory Operation Rules

For all Emergencies – dial 911

- **No unauthorized access**
- **No loaning of keys or keycards**
- **No unauthorized chemicals**
- **No unauthorized solutions**
- **No unlabeled solutions**
- **No food or drinks**
- **No bare legs or open-toed shoes**
- **No chemicals in wastebaskets**
- **No unwashed bottles in waste baskets**
- **No unauthorized use of equipment**
- **No pencils or spiral bound notebooks**
- **Be neat, Be clean, Be Safe**
- **Be courteous and clean up**
- **Wear protective gear**
- **Read Safety Data Sheets**
- **Know emergency procedures**
- **Read the signs, instructions and notices**
- **Ask if you have questions or don't understand**
- **Think before you act**

You can lose access to the laboratory if you violate any of the laboratory policies, safety rules, or cause injury to personnel or damage equipment.

Short and Simple Chemical Safety Rules

- **Know the chemicals you use. Material Safety Data Sheets (MSDS) are available.**
- **Wear gloves when handling or working with any chemical.**
- **Any use of acids must be performed only at the Acid benches. For Hydrofluoric Acid you must use full apron, nitrile gloves, and a face shield.**
- **NEVER mix acids and solvents – this can result in an explosion.**
- **NEVER add water to acid (NAW) - it can splatter violently.**
- **Always add acid to water (AAA).**
- **Perchloric acid is strictly prohibited.**
- **Hydrofluoric acid (HF) is commonly used in silicon processing. It is especially dangerous in that there is no immediate symptom of pain, but severe damage to the bone can result over a few hours. Take extreme care when using HF.**
- **Know where the nearest eyewash station is. If a chemical gets in your eye, call for help and flush eyes for at least 15 minutes.**
- **Solvents are highly flammable. Keep them away from any ignition source.**
- **Properly label all chemical containers: Name, Date, & Contents.**
- **Never leave chemicals unattended without identification.**
- **For reasons of contamination NEVER put any chemicals back into their original containers.**
- **Pour only the necessary amounts of chemicals you are planning to use.**
- **Proper chemical disposal is mandatory.**
    - **HF waste must be put in an appropriate container for pickup & disposal (Empty waste bottles are stored in the center "Acid Storage Cabinet" on the bottom shelf in Room 244.) The bottle must be clearly labeled "HF waste".**
    - **Acetic acid waste must be put in an appropriate container for pickup & disposal (Empty waste bottles are stored in the center "Acid Storage Cabinet" on the bottom shelf in Room 244.). The bottle must be clearly labeled "Acetic acid waste".**
    - **Acids (except HF and acetic acid!) must be collected in the acid waste containers in the hoods in 228, 244, and 247B.**
    - **Bases must be collected in the base waste containers in the hoods in 228, 244, and 247A, and 247B.**
    - **Solvents must be disposed of in the proper solvent waste containers (located in Rooms 247A & 247B).**

1.0 GENERAL LABORATORY PROCEDURES

There are many users of the laboratory. Common courtesy, common sense, respect for others, knowledge of the hazards, and cleanliness are all essential parts of laboratory operation.

1.1 BEHAVIOR IN THE LABORATORY

1. Laboratory users shall act in a professional manner at all times.
2. Horseplay and practical jokes are expressly forbidden.
3. Never work alone at a potentially dangerous activity.
4. Visitors to the laboratory must observe all safety regulations, including, but not limited to the wearing of a lab coat (or bunny suit), a hair net, and eye protection.
5. Laboratory users shall be aware of the location and proper operation of laboratory safety equipment.
6. Any chemicals in a hood must be labeled and have the user's full name printed on a clean room wipe, the date, and the chemical.
7. Use of mercury-based thermometers in the laboratory is not permitted at any time. Glass thermometers are discouraged; use of thermocouple or electronic temperature sensors is preferred.

1.2 AVOIDANCE OF ROUTINE EXPOSURE

1. Always avoid skin contact with chemicals.
2. Do not smell or taste chemicals.
3. Never pipette by mouth. Use a vacuum or a pipette bulb.
4. Apparatus which may discharge chemical vapors or dust that might produce adverse toxic effect must be vented into local exhaust devices.
5. Chemical reactions involving two or more substances may form reaction products that are significantly more toxic than the starting reactants. Always assume that all substances of unknown toxicity are toxic.
6. Always use common sense, good judgment, professional expertise and safety awareness when it comes to hazardous chemicals.

1.3 PERSONAL HABITS IN THE LABORATORY

1. Eating, drinking, chewing gum and cosmetic application are not permitted in the laboratory.
2. Smoking is not allowed in the laboratory.
3. Food must not be stored in a refrigerator with chemicals. Do not use glassware or utensils which are used in laboratory operations.
4. Confine all hair inside the hair net.
5. Wash hands before using the restrooms, eating, drinking, or smoking.
6. Wash hands upon exiting the laboratory area.

1.4 UNATTENDED OPERATIONS

1. Only well understood processes will be permitted to run unattended.
2. Laboratory lights should be left on 24 hours.

1.5 HOUSEKEEPING

There is a limited amount of storage space inside the laboratory. Each user is issued one (1) plastic bin for storage of glassware and samples, but these storage bins are NOT for storage of chemicals. A smaller number of lockers and cabinets are available for student use. These should be used for keeping only currently needed samples, masks, etc. Chemicals are to be stored only in the designated chemical cabinets. Items left out or in unassigned areas will be disposed of.

1. Clean up after yourself (dispose of chemicals, wipes, pipettes, etc.)
2. Lab areas (benches, hoods, tables, etc.) will be kept clean and uncluttered.
3. Any spills or accumulations of chemicals on work surfaces shall be removed as soon as possible with techniques that minimize residual surface contamination.
4. Floors and walkways should be kept dry at all times.
5. Doorways and walkways shall not be blocked or used for storage.
6. Access to exits, emergency equipment, and utility controls shall never be blocked.
7. For those that do not follow the rules, there are penalties:
    a) 1st time offense: The laboratory manager will pick up your glassware, chemicals, samples, etc., and *you* will have to see the laboratory manager before you get the items back.
    b) 2nd offense: The laboratory manager will pick up your glassware, chemicals, samples, etc. and *you and your advisor* will have to make an appointment to see the laboratory manager before you get the items back.
    c) 3rd offense: The laboratory manager will pick up your glassware, chemicals, samples, etc. and *you and your advisor* will have to go before the lab committee

1.6 PERSONAL PROTECTION

There are numerous hazards in the laboratory. Each user is responsible for and required to use and know the types of protective equipment available. Everyone entering the laboratory must wear the appropriate eye protection, hair net, and gown as a minimum of protection while inside.

1.7 GLASSWARE

Glassware is used throughout the laboratory. The use of glass thermometers is strongly discouraged in the laboratory. Use electronic temperature monitoring devices (e.g. thermocouples, resistive thermal devices) instead. The use of mercury-based thermometers is strictly forbidden in the laboratory at all times. For general lab glassware, care should be taken in handling and use. Before use, the glassware should be inspected for any defects and cracks. Several pieces of the glassware in the laboratory have ground joints. These joints should never be put on tightly, especially at temperature extremes, because this can cause them to get stuck. All broken glassware (beakers, pipettes, silicon wafers, etc.) should be disposed of in the plastic bin in Room 244 labeled “Broken Glass”. Broken III-V wafers and III-V materials to be discarded should be placed in the “III-V waste” bin in room 244 by the broken glass bin for disposal.

1.8 WORKING WITH VACUUM

In a vacuum system, the higher pressure is on the outside, rather than on the inside, so a break can cause an implosion rather than an explosion. The resulting hazards consist of flying glass and damage from this debris. Special precautions including eye protection are required.

1.8.1 Glass Bell Jars

Glass bell jars at reduced pressure are capable of collapsing violently either spontaneously (if cracked or weakened in some other way) or from an accidental blow. Adequate shielding must be in place. It is advisable to check the bell jar at each use. Only thick walled flat-bottomed bell jars specifically designed for operation at reduced pressure should be used.

1.8.2 Dewar Flasks

Dewar flasks are capable of collapsing as a result of thermal shock or a slight scratch by a stirring rod. They must be shielded, by enclosing them in a wooden or metal container. This reduces the hazard of flying glass in case of collapse.

2.0 CHEMICALS

All users of the laboratory should know as much as possible about the chemicals being handled and used for processing. Read the container label, material safety data sheets, literature in the library and or consult with your supervisor, PI or the Chemical Hygiene Officer at the Risk Management and Safety Office.

Prior to bringing any new chemical into the lab, the user must have the MSDS (Material Safety Data Sheet), be aware of the storage requirements and have a place to store it, know the proper handling procedures, have a disposal procedure for the chemical, have any necessary PPE (Personal Protective Equipment), and inform the lab director so that this information can be evaluated and reviewed for proper safety procedures.

The MSDS list for all the chemicals in the microelectronics laboratory can be accessed by going to the following link: http://www.ee.nd.edu/ndnf/MSDS%20list.xls. The MSDS sheets for all chemicals used inside the microelectronics lab are located just inside the door of Room 244. These MSDS sheets are there for emergencies and should only be removed from the binders in an emergency. If you need an MSDS sheet please contact the Laboratory Manager.

No chemicals are to be stored in your lab bin! These bins are for glassware and sample storage. If you buy a new chemical and bring it into the lab, you are responsible for getting the MSDS sheet and submitting a copy of it to the Laboratory Manager. The Material Safety Data Sheets are maintained by the Laboratory Manager for all chemicals used in the laboratory. Chemicals that are specially ordered for you/your project/your professor should be labeled as such with your name, date, and professor or person responsible for it. Small amounts of chemical solutions that are made up and stored in an acid or solvent cabinet must be labeled. The label will have your name, date and chemical composition.

Chemical guidelines for use inside the laboratory on the benches and hoods:

1. All containers with chemicals must be labeled.
2. A cleanroom wipe with your FULL name and date must be under all containers with chemicals in them. Use a ballpoint pen so that your writing will be legible.
3. NO chemicals will be left overnight unless ABSOLUTELY necessary! If it has to be left overnight, then the time must be included and you will return within 24 hours to pick up these items.
4. Chemicals left overnight may NOT be left more than 24 hours!
5. NO glassware may be left overnight to "air dry".
6. When using a bottle containing a chemical, use all of it before opening a new bottle.

Laboratory users not following the guidelines will face the following sanctions:

a) 1st time offense: The laboratory manager will pick up your glassware, chemicals, samples, etc and *you* will have to see the laboratory manager before you get the items back.
b) 2nd offense: The laboratory manager will pick up your glassware, chemicals, samples, etc and *you and your advisor* will have to make an appointment to see the laboratory manager before you get the items back.
c) 3rd offense: The laboratory manager will pick up your glassware, chemicals, samples, etc and *you and your advisor* will have to go before the lab committee.

2.1 PROCUREMENT

1. All chemicals used and brought into the Laboratory must have the approval of the Laboratory Director.
2. Prior to purchasing the following must be considered:
    a. Proper storage and handling procedures
    b. Are facilities adequate to safely handle the material
3. A material safety data sheet (MSDS) is required for all chemicals brought into the laboratory, this is the responsibility of the person bringing the chemical into the laboratory. Check the on-line list of lab chemicals at http://www.ee.nd.edu/ndnf/MSDS%20list.pdf or with the Laboratory Manager to see if the MSDS is already on file.
4. No chemical will be allowed in the laboratory without an identifying label.
5. Order only what you need.
6. All chemicals brought into the laboratory must have a date on the chemical container when ordered and the person responsible for the chemical.

2.2. CHEMICAL WASTE DISPOSAL

Each user working in the laboratory has a responsibility to see that all chemical wastes they generate are disposed of properly. Prior to using any chemical, a lab user MUST be sure that they understand the proper disposal procedures; starting a process without knowing the proper procedures for disposing of the chemicals and byproducts is a serious violation of lab safety rules. It is the responsibility of each lab user to know if the chemicals they are using are acids, bases, solvents, etc., and how each is to be disposed of. Users should be aware that under no circumstances can solvents be flushed down the drain. Additionally, no solution

with a pH < 2 or pH > 12 can be disposed of down the drain. As nearly all acid and base solutions used in common semiconductor processing exceed these limits, the following guidelines will be followed for disposal of chemicals:

1. All solvents must be put in one of the solvent waste containers either in Room 247A or 247B.
2. Any solution containing Hydrofluoric Acid must be put in a waste container and labeled as such for proper disposal. Empty waste HF bottles are stored in the center "Acid Storage Cabinet" on the bottom shelf in Room 244.
3. All acids (except HF) are to be put in the acid waste containers in Rooms 228, 244, or 247B. Users should not carry waste acid solutions outside of the hoods in which they are processing; use the waste container within the acid hood being used.
4. All bases are to be put in the base waste containers in Rooms 228, 244, 247A, and 247B. Users should not carry waste base solutions outside of the hoods in which they are processing; use the waste container within the hood being used.

All questions about disposal of a chemical must be addressed prior to starting work. See your advisor, the lab director, or Risk Management and Safety (1-5037). Never leave any chemical container uncapped, especially waste containers.

2.2.1 CHEMICAL WASTE CONTAINER DISPOSAL

Empty chemical bottles or containers should not be left out, but should be disposed of immediately! Solvent and acid containers should be triple rinsed with water (the rinse water may be dumped down the drain of an acid hood), the label defaced, and then put into the trash bins with the cap off. Other chemical containers may need a pre-rinse prior to a triple water rinse before disposal (e.g. photoresist bottles should be pre-rinsed several times with acetone until it rinses clear.) The proper procedure is: rinse the container, deface the label, and discard in the trash with the cap off.

2.3 HANDLING

1. When chemicals are hand carried, the container should be placed in a secondary container to protect from breakage and spillage.
2. Freight elevators should be used when possible to prevent exposure to people on passenger elevators.
3. If a wheeled cart is used, it should be stable under the load and have wheels that are large enough to handle uneven surfaces without tipping over or stopping suddenly.
4. The "tote" part of the cart should have sides to prevent roll or drop offs.

2.4 FLAMMABLE LIQUIDS

Solvents are a necessary part of the NDNF laboratory and have the potential for causing a considerable amount of damage if handled incorrectly. The laboratory maintains numerous solvents. All of these containers are limited to 1 gallon or less. The solvents shall always be stored in the flammable locker cabinet, which are located inside the laboratory.

2.4.1 HAZARDS

1. Vapors can form an ignitable mixture in air.
2. Many flammable liquids are solvents and are potentially hazardous by inhalation.
3. Skin contact should be avoided, irritation or skin absorption are possible with some chemicals.
4. Damage to the eyes can range from irritation to severe damage.

2.4.3 STORAGE

Store all flammable liquids and solvents in solvent cabinets, which are located inside the laboratory.

2.4.3 CONTROLS

1. Chemicals must be in a fume hood.
2. Spills must be cleaned up immediately and the spill area decontaminated.
3. Emergency showers and eyewashes shall be used when skin or eye contact occurs. Get first aid attention immediately.
4. Care should be taken when using hotplates to heat flammable liquids. Many models of hotplates are not intrinsically safe. (The heating element is not sealed). Vapors can travel under the plate and ignite. Use heating mantles whenever possible.

2.5 CORROSIVE CHEMICALS

A corrosive chemical is a chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.

2.5.1 HAZARDS

Contact with skin, eyes, respiratory or digestive tract causes severe irritation or burns.

2.5.2 STORAGE

Store all acids and bases in an acid cabinet, which are located inside the laboratory.

2.5.3 CONTROLS

1. Wear protective clothing: goggles, face shield, lab coat, lab apron, and latex or nitrile gloves.
2. Never add water to concentrated mineral acids or bases – add the acid or base to water (remember: Always add acid: AAA).
3. In case of skin contact:
   a. Flush affected area with large amounts of water for at least 15 minutes.
   b. Remove contaminated clothing.
   c. Seek medical attention.

2.6 REACTIVES

A reactive (unstable) chemical is one, which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense or will become self-reactive under conditions of shock, pressure or temperature.

2.6.1 HAZARDS

1. Water sensitive chemicals react violently in the presence of water.
2. Pyrophoric materials ignite in air at or below room temperature in the absence of added heat, shock or friction.

2.6.2 STORAGE

1. Store water reactives according to label directions.
2. Pyrophorics should be stored in an atmosphere of inert gas.

2.6.3 CONTROLS

1. Wear proper safety equipment.
2. Read precautionary label.
3. Use only in a hood/glove box.

2.7 COMPRESSED GASES

The laboratory has numerous compressed gas cylinders for various applications throughout the laboratory. The pressure inside some of these cylinders can exceed 2500 PSI. Both empty and new full cylinders are stored in the East Bay of Cushing Hall. All of the cylinders belonging to the EE department are marked with a RED triangular tag over the top of each cylinder. Do not use another department's cylinders!

All gas cylinders are delivered to the East Bay dock area of Cushing Hall. The full cylinders of gases are placed on the South wall of the bay on the left hand side under the sign that says "Full Cylinders". Empty cylinders should be returned to the right hand side, under the sign that says "Empty Cylinders". Gas cylinders are normally delivered on Fridays, please plan accordingly for your experiments. Notify the lab manager about gases that you plan to use so that the order can be placed. Also, specialty gases may take some time to arrive; this needs to be taken into account for your experiments and timetable. ***Return empty cylinders to the dock area, do not leave them on the gas carts!*** The gas carts must be returned to room 247 after each use.

2.7.1 HAZARDS

Compressed gases may be flammable, toxic or corrosive. Because of the pressure, a gas cylinder with a broken valve (e.g. from dropping a cylinder) can become a missile capable of penetrating walls.

2.7.2 HANDLING, STORAGE AND USE

1. General Standards
   a. All compressed gas cylinders must be secured to wall or lab bench.
   b. Leave the valve safety caps in place except when the cylinder is in use.
   c. Cylinders shall be clearly marked with the content name. Do not remove or deface labels, decals, etc., provided by the supplier for identification.
   d. A pressure regulator shall be used to control the flow of gas from a cylinder.
   e. Never attempt to repair or alter cylinder valves or safety relief devices.
   f. Use only an approved handcart to transport cylinders. Cylinders are heavy and can be difficult to properly position for some users. If you need help, contact laboratory personnel or other lab users for assistance.

g. Empty cylinders should be returned to the dock area for pick up. They may not be left on a cart.

2. Pressure Regulators and Needle Valves
   Needle valves and regulators are designed specifically for different families of gases. Use only the properly designed fittings.
   a. Threads and surfaces must be clean and tightly fitted. Do not lubricate.
   b. Tighten regulators and valves firmly with the proper size wrench (Avoid using adjustable wrenches or pliers as they can damage nuts). Do not force tight fits.
   c. Open valves slowly. Do not stand directly in front of the gauges. (Gauge face may blow out). Do not force frozen valves.
   d. Shut off cylinders when not in use.
   e. Use new or good tubing to transfer toxic gases from pressurized cylinders.
   f. Seal the threads on the needle valve with Teflon tape.

3. Leak Testing
   Cylinders and connections should be tested by "Snoop" or a soapy water solution.

2.8 LIQUID NITROGEN

Liquid nitrogen has a temperature of about –320^{o}F in its liquid form. When exposed to higher temperatures this product converts to a gas very quickly. This product does not contain oxygen and may cause asphyxia if released in a confined area. Contact with this product may cause frostbite or freeze burns to exposed tissues. Ensure that the area you are working in is well ventilated and if dispensing this, you have the proper personal protective equipment (PPE).

Individuals working with liquid nitrogen should wear eye protection and gloves or use protective thermal pads to avoid "burns".

The full liquid nitrogen containers are delivered to the West dock area of Fitzpatrick Hall. The empty containers should be returned to the West dock area. The containers should be brought up using the freight elevator. See the EE office for a key to the freight elevator if you need to get a full container or return an empty container.

When transporting a full liquid nitrogen container, ***ALWAYS PULL THE CONTAINER!*** Never push a full container. This may cause the container to tip over and cause a large release of nitrogen and deplete the oxygen in the immediate area.

Liquid nitrogen containers are normally delivered on Tuesdays and Thursdays, please plan accordingly for your experiments. Notify the lab manager about your planned usage of liquid nitrogen so an order can be placed.

3.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The Laboratory Director and or the PI for the user (or authorized representative) will be responsible for the selection of personal protective equipment, acquiring approved equipment, maintaining availability, and establishing cleaning and disposal procedures. Chemical protective clothing must be removed before leaving the work area.

1. Personnel must know the types of protective equipment available and use the proper type for each job. Everyone, including visitors, must wear the appropriate eye protection in the lab.
2. Wear appropriate gloves when handling hazardous chemicals.

3.1 EYE PROTECTION

1. Safety glasses with side shields are required.
2. Face shields with safety glasses underneath or chemical splash goggles are required when transferring or pouring acid or caustic materials, or where a potential splash exists.
3. Inspect before each use the eye and face protection you plan to use. If there is any damage, cracks, debris, or scratches do not use it! Notify laboratory personnel immediately.

3.2 GLOVES

1. Chemical resistant gloves shall be worn whenever the potential for skin contact with hazardous materials exists.
2. Gloves shall be removed before touching other surfaces (door knobs, telephone receivers, faucet handles).
    a. Heat resistant gloves shall be used for handling hot objects.
    b. Low temperature gloves specifically designed for cryogenic use shall be worn when handling materials like dry ice or liquid nitrogen.
3. Before each use, gloves are to be inspected for damage and contamination, If there is any damage, cracks, or contamination do not use them and notify laboratory personnel immediately.

3.3 CLOTHING

1. No sandals or open-toed shoes are to be worn in the lab. Canvas shoes should be avoided.
2. The shoe should have a non-skid sole and should have a reasonable heel height.
3. Laboratory coats must be worn by users whenever in the microelectronics laboratory.
4. Skirts and shorts are not allowed to be worn in the laboratory as they provide little protection from a potential splash or chemical spill.

3.4 RESPIRATORS

If any user has a need for a respirator, please consult with your PI and Risk Management & Safety for the selection of this Personal Protective Equipment (PPE).

3.5 EMPLOYEE TRAINING (PPE)

Employees should not use any Personal Protective Equipment until they have received instruction on the proper selection, use, and limitations of the equipment.

4.0 EMERGENCY EQUIPMENT

4.1 GENERAL

Each laboratory user shall be familiar with the location of the fire alarms (pull stations), telephone, emergency numbers, and chemical containment devices. See the Laboratory Layout at the end of this manual for the location of these items.

4.2 SAFETY SHOWERS AND EYE WASHES

There are two safety showers and two eye wash stations in the laboratory. The safety showers are near the double door entrances for Rooms 244 & 247. One of the eyewashes is located near the acid bench and double door entrance of Room 244. The other eyewash is located in Room 247 next to the solvent bench. See the Fire Alarm & Safety Item Location drawing in the appendix for the location of these items. When first using the laboratory, familiarize yourself with these locations.

4.3 Lab Coats and Personal Clothing

A lab coat or clothing that has been exposed to a chemical spill or splash should be removed immediately. The severity of contamination will determine how much of the clothing will be removed. Temporary clothing is available for emergencies. By each shower (near the North entrances to Room 244 & 247) is a plastic bag containing a new lab coat for temporary use. Additionally, inside the supplies locker in Room 228 are three (3) more plastic bags. Each bag contains socks, sweat pants, and a sweatshirt, with a pair of shower shoes on top of the bag. The sizes are small, medium, and large in each bag.

5.0 EMERGENCY PROCEDURES

No single emergency plan will be adequate for all emergency situations. The most important component of emergency planning is prevention. Prevention measures range from employee training to facility inspections. **If a fire alarm sounds, all persons are to leave the laboratory immediately.** Never assume that it is a drill. If there is any question about any situation or something happening in the laboratory, always ask (ND Fire Dept., your PI, Lab Manager, or others). It is better to err on the side of caution.

5.1 EMERGENCY REPORTING PROCEDURES

Call the Security Department (911) for all emergencies. They will dispatch the Police, Fire Department, medical aid, or Risk Management and Safety.

FOR ALL EMERGENCIES DIAL 911

When reporting an emergency, give as much information as possible, such as:

1. Location and type of emergency
2. Name of victim (if necessary)
3. Your name
4. Extension number of caller
5. If a chemical is involved, write down the name to give to emergency personnel.
6. If possible, remain at the scene to help explain what happened.

5.2 FIRST AID and MEDICAL ATTENTION

Accidents or injuries, which occur in the laboratory and require medical treatment, should be treated immediately. During normal working hours (8-5, M-F) contact laboratory personnel for assistance and University Health Services will administer medical attention or make a referral for other treatment or facilities. After hours, security (1-5555) should be contacted. For accident victims who need medical care beyond first aid, call Security (911) for transportation to the proper medical facility. In any case where you are not sure of the severity of the injury or where the employee should be referred to, they should be immediately sent to University Health Services. All incidences of injury in the lab must be reported the lab director within 24 hours.

FIRST AID PROCEDURES

1. CHEMICAL BURNS: Flush the affected area with cold water for at least 15 minutes. Flush eye for at least 15 minutes at an eye wash station or sink.
2. THERMAL BURNS: Immerse the burned area in cold water or apply ice until the pain stops. Cover with a sterile dressing.
3. POISONS: Call the Poison Center (1-800-382-9097) for assistance in administering poison antidotes.
4. BLEEDING: Hold a clean cloth pad directly on the wound and apply hand pressure. Apply a tourniquet only as a last resort.
5. FIRES: Put out burning clothing or hair with a cotton lab coat, fire blanket or water. If these resources are not available, make the victim roll on the ground to put out the flames.

5.3 CHEMICAL SPILLS

When lab spills occur, it is necessary to take prompt and appropriate action. Appropriate action will depend on the severity of the hazards associated with the particular chemical

1. If the spill is minor and of known limited danger, begin the cleanup operation immediately.
2. If the spill is unknown in chemical composition or potentially dangerous (explosive, toxic fumes), evacuate the room and call Risk Management and Safety at 1-5037 during business hour (8-5) or Security at 911 or 1-5555 for weekend or outside of business hours.
3. If it is suspected or known that the spill is extremely dangerous:
    a. Call Security (911) who will alert the Fire Department and Risk Management and Safety.
    b. Evacuate the building by pulling the nearest fire alarm pull station. See the Fire Alarm & Safety Item Location drawing in the appendix for location.

5.4 CHEMICAL SPILL CLEANUP

Spill control begins by spreading an absorbent material, like vermiculite, on the spill. Spill cleanup kits are superior alternatives to vermiculite. Kits are made specifically for acids, alkalis, organic solvents and mercury and are available through RMS or lab supply

companies. These kits have many times the absorbent capacity of vermiculite. Kitty litter may also be used as a substitute for vermiculite. Each laboratory has appropriate spill absorbents available in the lab for the types of chemicals that are stored or used in the laboratory. These are located on top of the acid or solvent cabinets. After allowing the chemical to absorb, scoop up the vermiculite and deposit it into a plastic disposal bag. Wipe up the contaminated surface with soap and water and a sponge immediately and place in the disposal bag. Tie the bag and label it with a chemical discard tag. Call Risk Management and Safety (1-5037) for disposal procedure or pickup. If in doubt about the proper spill cleanup procedures, call Risk Management and Safety.

6.0 LABORATORY USER ORIENTATION & TRAINING

All new users of the laboratory must read the "Notre Dame Nanofabrication Facility, Laboratory Operations & Safety Procedures Manual", (this document) before access to the laboratory and equipment is granted.

6.1 CHEMICAL TRAINING

It is the responsibility of the laboratory user to become familiar with the chemicals that they are using.

6.2 EQUIPMENT TRAINING

There are numerous users of the equipment in the laboratory and, as such, certain pieces of equipment have logbooks. To use this equipment, a user must follow the procedures for the equipment and logbook. If you do not follow the procedures for the equipment usage, your authorization to use the equipment will be denied.

1. Equipment with signup sheets and logbooks must be filled out completely. If you sign up to use equipment and do not show up within 10 minutes of the time signed up for YOU LOSE YOUR TIME SLOT.
2. Only "authorized users" are allowed to sign up and use equipment. (Personnel that are trained on the equipment by staff or faculty are considered "authorized users".)
3. If you are not an authorized user, DO NOT USE THE EQUIPMENT!
4. Authorized users are NOT allowed to train others.
5. Report any problems as they occur, give a complete description of the problem ("It's broken" or "doesn't work" is not a description of the problem.) Sending e-mail to the lab manager or notifying a technician are good ways to report your problems. Include the equipment name, date, problem and time.
6. If you pull out equipment, racks, carts, step stools, etc. replace them in their proper position.
7. Keep the area around instruments and equipment clear of obstructing materials.
8. Equipment with frayed electrical cords should be reported immediately.
9. Penalties for unauthorized or misuse of equipment:
    a) 1st offense, you and your advisor will have to see the laboratory manager.
    b) 2nd offense, you and your advisor will go before the lab committee.

7.0 LASER SAFETY

Lasers are classified to describe the capabilities of a laser system to produce injury to personnel. This classification ratings are from Class I lasers to Class IV lasers. The laboratory has several pieces of equipment that use lasers (GCA 6300 Wafer Stepper, Gaertner Ellipsometer, Metricon Prism Coupler, Variable Angle Spectroscopic Ellipsometer, as well as a number of systems in the Electro-Optics Lab). Care should be taken when working around any of this equipment to avoid any undue exposure to the laser light.

Class I lasers are low powered devices that are considered safe from all potential hazards. (examples: laser printers, CD players, CD ROM devices)

Class II lasers are low power (1 m W), visible light lasers that could possibly cause damage to a person's eyes. (examples: classroom demonstrations, laser pointers, aiming devices and range finding equipment)

Class IIIA lasers are continuous wave, intermediate power (1-5 mW) devices. (examples: laser pointers and laser scanners)

Class IIIB lasers are intermediate power (c.w. 5-500 mW or pulsed 10 J/cm^2) devices. (examples: spectrometry, stereo lithography, and entertainment light shows)

Class IV lasers are high power (c. w. >500 mW or pulsed> 10 J/cm^2) devices. (examples: surgical lasers, research, drilling, cutting, welding, and micro-machining)

8.0 THE NDNF LABORATORY

8.1 Laboratory Layout

All users should be aware of the layout of the laboratory with respect to the following:

- Equipment location
- Fire extinguisher location
- Fire alarm pull station
- First aid box
  (See specified drawings in the Appendix for items listed above.)
- Chemical spill (large) containment
- HF antidote (Located on the top of the acid cabinet and the top of the First Aid box in room 244 and room 247B.)

8.2 Laboratory Alarms

There are various alarms and safety features built into the building and equipment for the Nanofabrication Laboratory.

8.2.1 Building or Laboratory Alarm

When a fire or fire alarm occurs for the laboratory (or building) always leave immediately. Never assume it is a false alarm and remain in the laboratory. (In fact, failure to leave the building during a fire alarm is illegal.)

The Vulcain alarm system (Room 247) is for the detection of silane or hydrogen gas in the laboratory. There is an annunciator panel that displays the current status of the system and any alarms. If one of the two gases is detected there will be a flashing strobe light and an audible tone. This alarm system is tied into the building fire alarm system. Therefore, the gas detection will set off the local Vulcain alarm and the building alarm. If this happens, leave immediately. This alarm will also shut down the delivery of silane gas to the associated equipment at the cabinet in the penthouse.

8.2.2 Equipment Alarms

The equipment location and their associated alarm(s) are shown in the appendix drawing titled "EMO & Alarm Locations". An asterisk on the drawing signifies the location of the alarm or some type of control to silence or reset an alarm of an EMO (Emergency Off) switch. With respect to any and all alarms associated with the equipment, laboratory personnel should be notified. Since the equipment-specific alarms in the lab are generally notification of a minor fault or a process problem (as opposed to a safety issue), you should notify lab personnel or other affected users (e.g. faculty advisor, other lab users) by email, voice mail, or in person. Outside of daytime working hours for the lab staff, a voicemail or email message to lab personnel and other affected users is sufficient unless you believe that the situation is more serious than a routine condition. Examples of non-routine problems that require more aggressive notification include fire in equipment, water leaks from any equipment or facility, equipment making unusual noises, etc. In non-routine cases, contact the lab manager (Mike Thomas) or lab director at home by telephone. Fires should always be reported to the Fire Department by pulling the fire alarm and calling 911.

The Thermco Furnace (Room 244) over temperature alarm will automatically shut down the "Element" power circuit breaker to the heating element. When this occurs the power indicator light next to the breaker will not be lit. If this breaker trips from this unit, notify lab personnel.

The blue box/cabinet on the south wall (Room 244) is a monitor for the room ventilation. An alarm for this unit is a small audible tone. This monitor beeps occasionally. If this alarm from this unit continually goes off, notify lab personnel.

The 6300 Stepper (Room 247B) has 2 alarms associated with this system. The first is the environmental chamber. This alarm (a continuous beeping sound) will be heard when the chamber is more than 2 deg. C above or below the set point. The second alarm is for the arc lamp power supply if there is a problem with the arc lamp itself or the power supply. This sound will be an intermittent beep. To silence this alarm, open

the lower panel door on the 19" equipment rack and turn off the power to the arc lamp power supply. This is the bottom unit and the power switch is the red toggle switch on the right side of the case. Notify lab personnel of this alarm or if you shut down the power supply.

The solvent and acid laminar flow benches (Room 247B) both have an alarm when the exhaust falls below a preset level. The exhaust error usually occurs for a relatively short time. Pressing the silence button on the upper left black panel in each hood can silence the alarm. If this alarm continually goes off, stop using the bench and notify lab personnel.

The CDO 859 (Room 247C) is a burn box and scrubber for silane and other exhaust gases from several pieces of equipment in Room 247. The alarm for this unit is a continuous tone and one or more of the LEDs on the front panel are red during an alarm, the normal operation color is green. An alarm for this unit will automatically shut down the delivery of Silane gas to the lab. Notify lab personnel of this alarm.

The Haskris heat exchangers (Room 247C) have an over temperature alarm. This alarm is a loud buzzing sound indicating that the unit is out of its temperature range. Notify lab personnel of this alarm.

The HVAC alarm control box for the silane storage in the penthouse is located in the northwest corner of Room 247. If there is a problem with the temperature control of this room a (very loud) buzzer will sound. There is a silence button on the control box for this along with a reset. Press the silence and reset button to stop the alarm and notify lab personnel of this alarm.

The Plasma Therm/RIE-790 (Room 247) has an alarm that is a modulated tone. This usually indicates a processing fault. This is the responsibility of the operator using it to reset this alarm. Notify the operator of the machine first, and if they cannot be located then notify lab personnel of this alarm.

The Unaxis PECVD (Room 247) has an alarm that is a modulated tone. This usually indicates a processing fault. This is the responsibility of the operator using it to reset this alarm. Notify the operator of the machine first, and if they cannot be located then notify lab personnel of this alarm.

The ASM/PECVD furnace (Room 247) is computer controlled. Any alarms, either audible or on the video monitor, that are associated with the machine are the responsibility of the operator. Notify the operator of the machine first, and if they cannot be located then notify lab personnel of this alarm.

The Alcatel DRIE A601E (Room 247) has alarms but all of them are accessed through the keyboard & video monitor on the front panel. These alarms usually indicate a processing or equipment fault. The alarms and the actions to be taken are the

responsibility of the operator. Notify the operator of the machine first, and if they cannot be located then notify lab personnel of this alarm.

8.2.3 Emergency Off (EMO) Switches

The equipment location and their associated EMO (Emergency Off) switches are shown in the appendix drawing titled "EMO & Alarm Locations". An asterisk on this drawing signifies the location of equipment alarms or an EMO switch to shut down or remove power to a piece of equipment. With respect to any use of an EMO associated with the equipment, laboratory personnel must be notified (email, voice mail, or verbally).

The EMO switches should be pressed only in an emergency. An emergency would be fire or smoke, an injury to anyone in the lab associated with a particular piece of equipment, a large spill of chemicals or water that might be a fire or electrocution hazard or any other similar situation.

The Thermco Furnace (Room 244) has several EMO switches that will remove power from the main heating elements in an emergency. When the EMO is pushed there will be a continuous buzzing sound from one of the two power distribution panels located behind the furnaces. Of the two power panels, one is for the north bank of furnace tubes and the other power panel is for the south bank. Whenever the EMO is pressed, laboratory personnel should be notified of this and any other information regarding the shutdown operation.

The 6300 Stepper (Room 247B) has a power switch on the front of the environmental chamber that can be used to shut down power to the chamber in an emergency. Notify lab personnel if the EMO is operated.

The CDO 859 (Room 247C) has an EMO switch on the front panel for emergency shut down of the unit. An alarm or EMO switch activation for this unit will automatically shut down the delivery of silane gas to the lab. Notify lab personnel if the EMO is operated.

The vacuum pumping station for the General Air CVD has 2 EMO switches to shut down the system in an emergency. One of the switches is location in Room 247C next to the pumping station on the wall and the other is located on the opposite side of the wall in Room 247. Notify lab personnel if the EMO is operated.

The Vulcain alarm system (Room 247) is for the detection of silane or hydrogen gas in the laboratory. There is an EMO switch next to the annunciator panel; this will shut down the delivery of silane gas to the laboratory. Use this EMO to shut down the silane gas if there is a problem with it or the equipment using it. Notify lab personnel if the EMO is operated.

The Plasma Therm/RIE-790 (Room 247) has an EMO switch to shut down the system in an emergency. The switch is located on the lower front panel of the machine. Notify lab personnel if the EMO is operated.

The Unaxis PECVD (Room 247) has two (2) EMO switches to shut down the system in an emergency. One switch is located on the lower front panel of the machine and the other is located on the power distribution panel behind the machine. Notify lab personnel if the EMO is operated.

The ASM/PECVD furnace (Room 247) has 2 EMO switches to shut down the system in an emergency. The switches are located on the front panel of the machine and near the keyboard/monitor rack. Notify lab personnel if the EMO is operated.

The Alcatel DRIE A601E (Room 247) has 2 EMO switches to shut down the system in an emergency. The switches are located on the upper front panel of the machine and the middle panel on the back. Notify lab personnel if the EMO is operated.

The UVO cleaner (Room 247) has an EMO switch to shut down the system in an emergency. The switch is located on the front panel of the machine. Notify lab personnel if the EMO is operated.

The RTP (Room 247) has an EMO switch to shut down the system in an emergency. The switch is located on the front panel of the machine. Notify lab personnel if the EMO is operated.

9.0 References:

Chemical Hygiene Plan UND: http://riskmgt.nd.edu/manuals/documents/CHP.pdf

APPENDIX

Definitions and Terms
The following terms are often encountered when reading about the properties of chemicals and the toxicity of chemicals, for example, on the Material Safety Data Sheets. Simple definitions are included here to help you understand the properties of common chemicals when referring to the MSDS or other references. This is not intended to be a complete reference on toxicology or chemical safety.

Acute Effects refers to the duration of the symptoms. Acute means symptoms lasting a few hours or days. Again, it has nothing to do with the severity of the effects.

Acute Exposure as used in toxicology refers to a short-term exposure. It has nothing to do with either the severity of the exposure or the severity of the effect. The type of exposure occurring during an accidental chemical spill is properly described as an acute exposure.

Allergies and Hypersensitivity are reactions by particular individuals to particular chemicals, caused by heredity or prior overexposure. Hypersensitive individuals should avoid exposure to the offending agents.

Carcinogen- A substance producing or inciting cancerous growth.

Chronic Effects are long-term effects, manifested by prolonged duration and continuing injury.

Chronic Exposure as used in toxicology refers to a long-term exposure. Again, it has nothing to do with the severity of the exposure, the severity of the consequences, or the duration of the consequences. Chronic exposures can be the result of chemicals in the workplace, the home, or the environment. Chronic exposures are usually the result of carelessness, ignorance, or neglect, and not the result of an accident.

Combustible Liquids: Combustible liquids shall mean any liquid having a flash point (closed cup) at or above 140° F and shall be known as Class III liquids. Class IIIA shall include those having flash points (closed cup) at or above 140° F and below 200° F. Class IIIB shall include those having flash points (closed cup) at or above 200° F.

Compressed Gas - any material or mixture having in the container a pressure exceeding 40 psia at 70 degrees F, or a pressure exceeding 104 psia at 130 degrees F; or any liquid flammable materials having a vapor pressure exceeding 40 psia at 100 degrees F.

Corrosive Material - any liquid or solid that causes visible destruction of human skin tissue or a liquid that has a severe corrosive rate on steel.

Corrosive Wastes - a material is corrosive if it is either highly acid or highly alkaline. The government defines limits of acidity at pH 2.0 and alkalinity at pH 12.5. Any waste that does not fall within these limits is considered corrosive.

Exothermic Reaction- A reaction, which produces heat (releases energy).

Explosive - any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion, i.e., with substantially instantaneous release of gas and heat, unless such compound, mixture, or device is otherwise specifically classified.

Flash Point: Flash point is the temperature at which a liquid has a vapor pressure sufficient to for an ignitable mixture in the air near the surface of the liquid. Open cup flash points vary several degrees higher than closed cup flash point.

Flammable Liquids: Flammable liquids shall be divided into two classes of liquids as follows:

1. Class I liquid shall include those having flash points below 100° F.
2. Class II liquids shall include those having flash points (closed cup) at or above 100° F and below 140° F.

Hazardous Material - is any solid, liquid or gas that is either ignitable, corrosive, reactive, or toxic.

Hazardous Waste - is any solid or liquid waste that is either ignitable, corrosive, reactive or toxic.

IDLH - Immediately Dangerous to Life and Health. This level represents the maximum value for which a 30 minute exposure will result in no irreversible or escape impairing effects, i.e. the maximum level that will not cause you to pass out or sustain irreversible organ damage. It is the value most appropriate to sudden, one time accidental exposures. For your information, a short table of values for relevant chemicals is listed below.

IDLH for several Chemicals

- Ammonia 500 ppm
- Carbon Monoxide 1500 ppm
- Chlorine 25 ppm
- Hydrogen Fluoride 20 ppm
- Diborane 40 ppm
- Phosphine 200 ppm

Ignitable Wastes - waste is ignitable if it can catch fire easily under conditions of routine handling. Chemicals such as fuels, solvents, paint and chemical wastes, and explosive wastes may often be ignitable.

Irritating Material- a liquid or solid substance which upon contact with fire or when exposed to air gives off dangerous or intensely irritating fumes, but not including Class A poisonous materials.

Local Effects occur in a small area, at the place of contact.

Local Exposure refers to exposure limited to a small area of skin or mucous membrane.

Mutagen- Capable of inducing mutations.

MSDS - Material safety data sheet.

NIOSH - National Institute of Occupational Safety and Health

Nonflammable Gas - any compressed gas other than a flammable compressed gas.

Organic Peroxide - any organic compound containing the bivalent -0-0- structure and which may be considered a derivative of hydrogen peroxide where one or more of the hydrogen atoms have been replaced by organic radicals must be classed as an organic peroxide.

OSHA - Occupational Safety and Health Administration.

Oxidizer - a substance such as chlorate, permanganate, inorganic peroxide, or a nitrate, that yields oxygen readily to stimulate the combustion of organic matter.

PEL - The permissible exposure limit (PEL), (or TLV Threshold Limit Value). Workers may be exposed to these substances for up to 8 hours per day 5 days per week. These values are published by OSHA, NIOSH, and ACGIH (American Conference of Governmental Industrial Hygienists)

Poison A - Extremely Dangerous Poisons: Poisonous gases or liquids of such nature that a very small amount of the gas, or vapor of the liquid, mixed with air is dangerous to life.

Poison B - Less Dangerous Poisons: Substances, liquids, or solids (including pastes and semisolids), other than Class A or Irritating Materials, which are known to be so toxic to man as to afford a hazard to health during transportation; or which, in the absence of adequate data on human toxicity, are presumed to be toxic to man.

PPE - Personal protective equipment.

Pyrophoric Material - Any material that ignites spontaneously in dry or moist air at or below 130 degrees C.

Reactive Wastes - Substances, which can explode or release poisonous vapor on contact with air, water, or other neutral liquids. Reactive wastes may often be produced in metal heat-treating and electroplating operations, in the production of explosives, in some leather finishing operations, and in many chemical manufacturing processes.

STEL - Short Term Exposure Limit. This value is the maximum concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from: irritation; chronic or irreversible tissue change; or narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the daily maximum exposure level also is not exceeded.

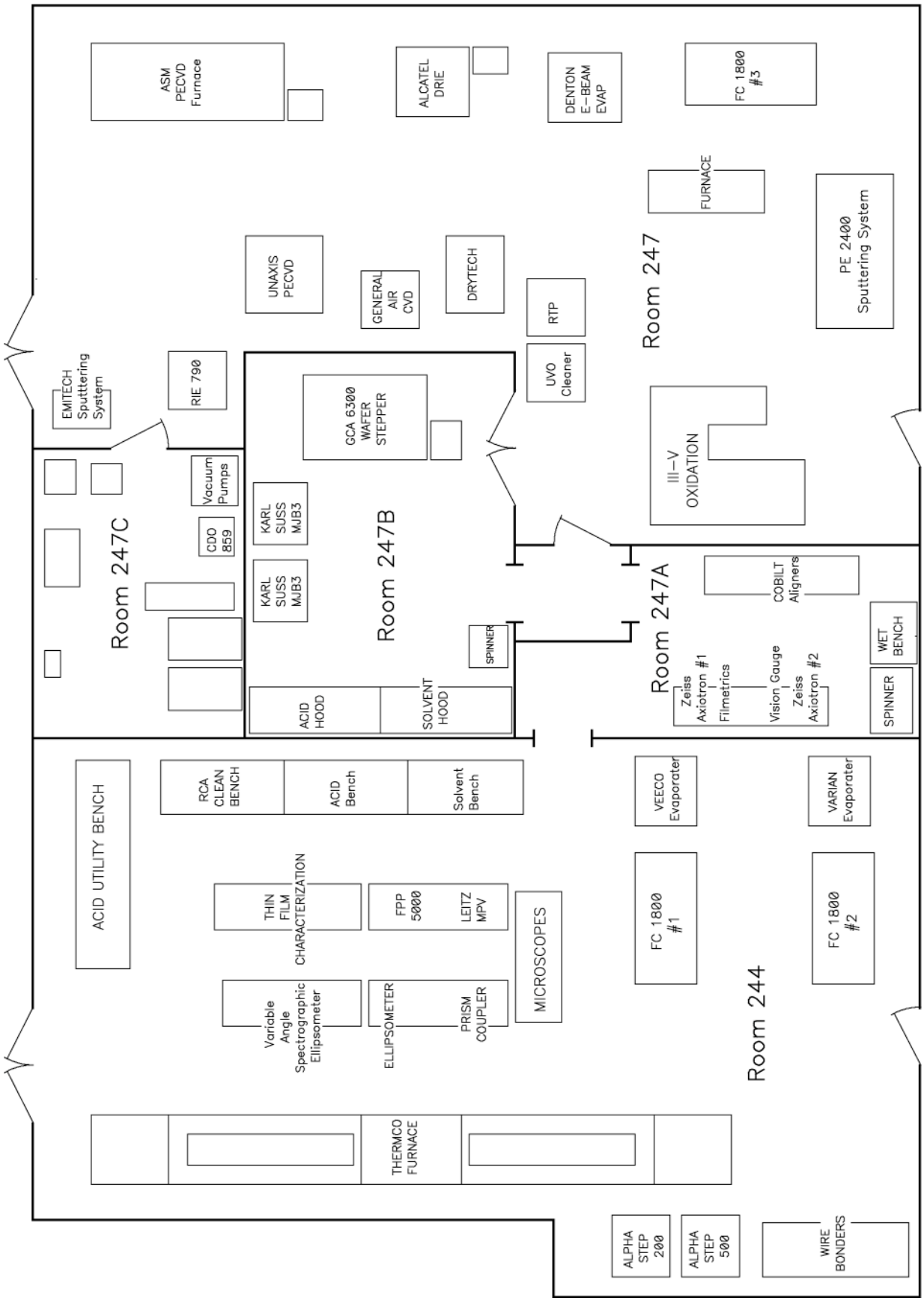
Systemic Effects occur throughout the body, or at least away from the point of contact.

Systemic Exposure means exposure of the whole body or system, through absorption, ingestion, or inhalation.

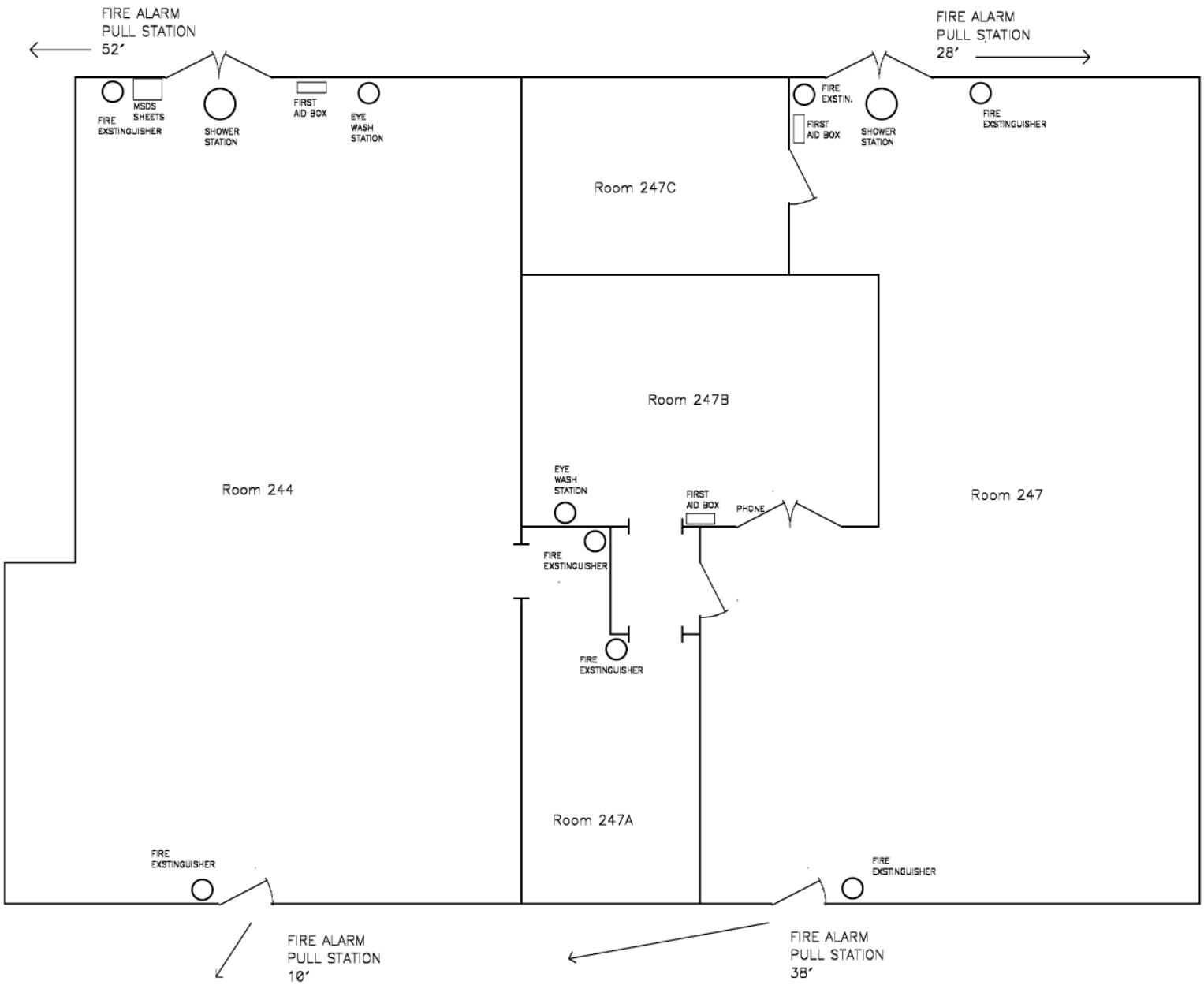
Teratogen- A substance causing damage or death to a fetus.

TLV - Threshold limit value. This is actually TLV-TWA (time weighted average) but is commonly called just TLV. It is the (averaged) level to which you can be exposed 8 hours a day, 5 days a week forever, without adverse health effects. These levels are set by ACGIH (governmental and industrial hygienists), and adopted into law by OSHA (Occupational Safety and Health Administration). This level is most relevant to chronic (long term) exposure to chemicals in the work place. Short term exposures in excess of TLV are thus not necessarily hazardous.

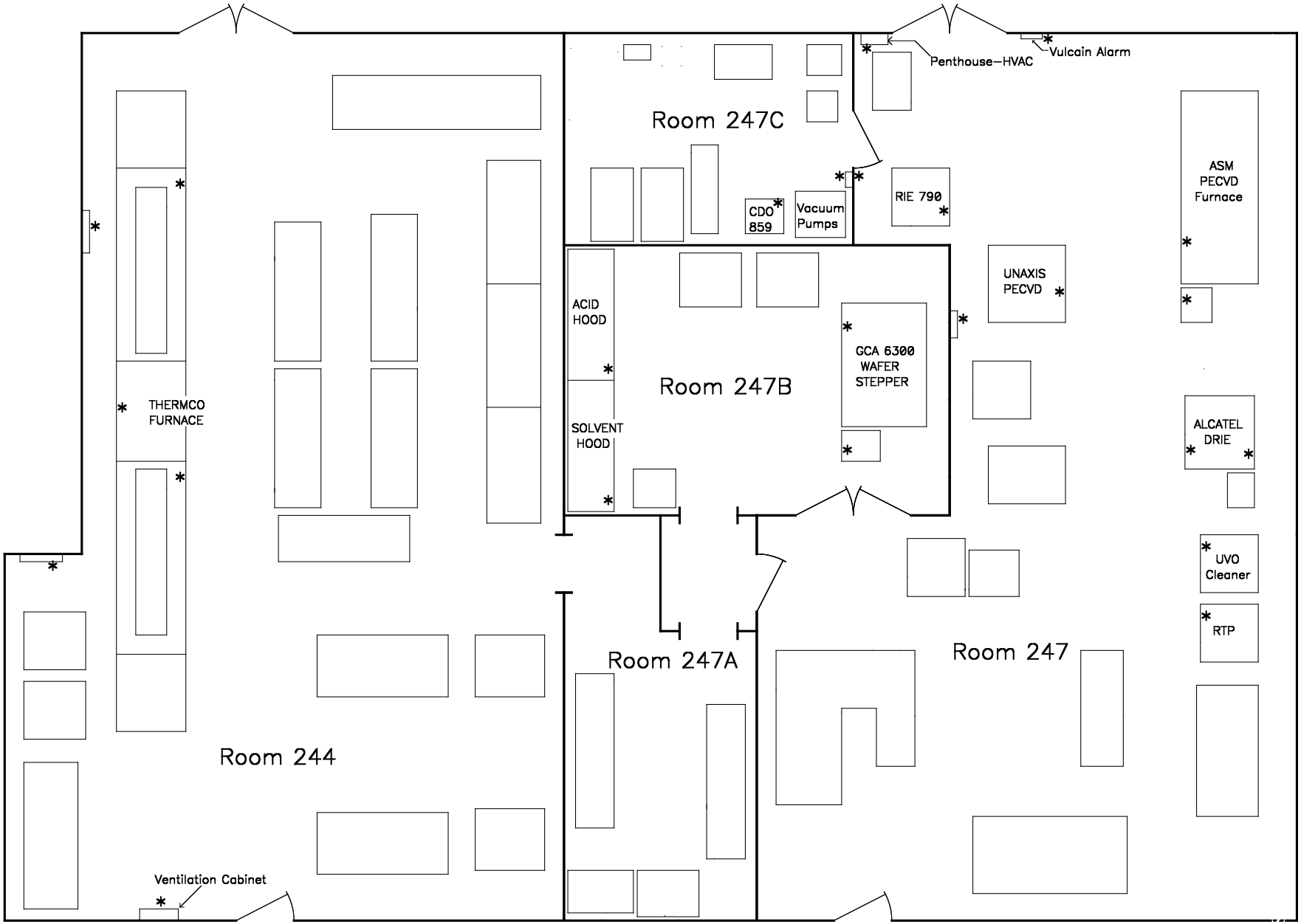
Toxic Wastes - wastes that are poisonous to human beings or other animals. Some are poisonous to the touch; others are harmful if inhaled; still others are toxic only if swallowed. Some produce immediate sickness, while others may not cause obvious symptoms for months or even a year.



Equipment Location



Fire Alarm & Safety Item Location



EMO & Alarm Locations

Information Data Base

All Nanofabrication Laboratory users and personnel:

In case of emergencies or important questions, we must have some information and several phone numbers on hand for all users of the lab as well as for full and part time people responsible for any lab functions.

Please fill out all applicable information.

Return completed form to the Laboratory Manager.

Check here if phone numbers are confidential.

Name _____

Email Address_____

Advisor's name and your role in the lab _____

Advisor's phone number _____

Area of research or course number _____

Your office room number and phone _____

Campus or local home phone number _____

Most likely phone number away from campus (e.g. parents home) _____

Who to notify in case of emergency:

Name _____

Relationship _____

Phone Number _____

For research projects, identify all utilized items that apply:

Chemicals:

Equipment:

Safety Manual Agreement

I have read and understood the ***Notre Dame Nanofabrication Facility – Laboratory Operations & Safety Manual, Rev. 3, August 15, 2005.*** I will abide by all laboratory regulations and understand that failure to abide by the regulations and failure to be responsible for others working in the laboratory can result in the loss of laboratory privileges.

Name (Print) _____

Signature _____

Date _____

Return this form to the Laboratory Manager.