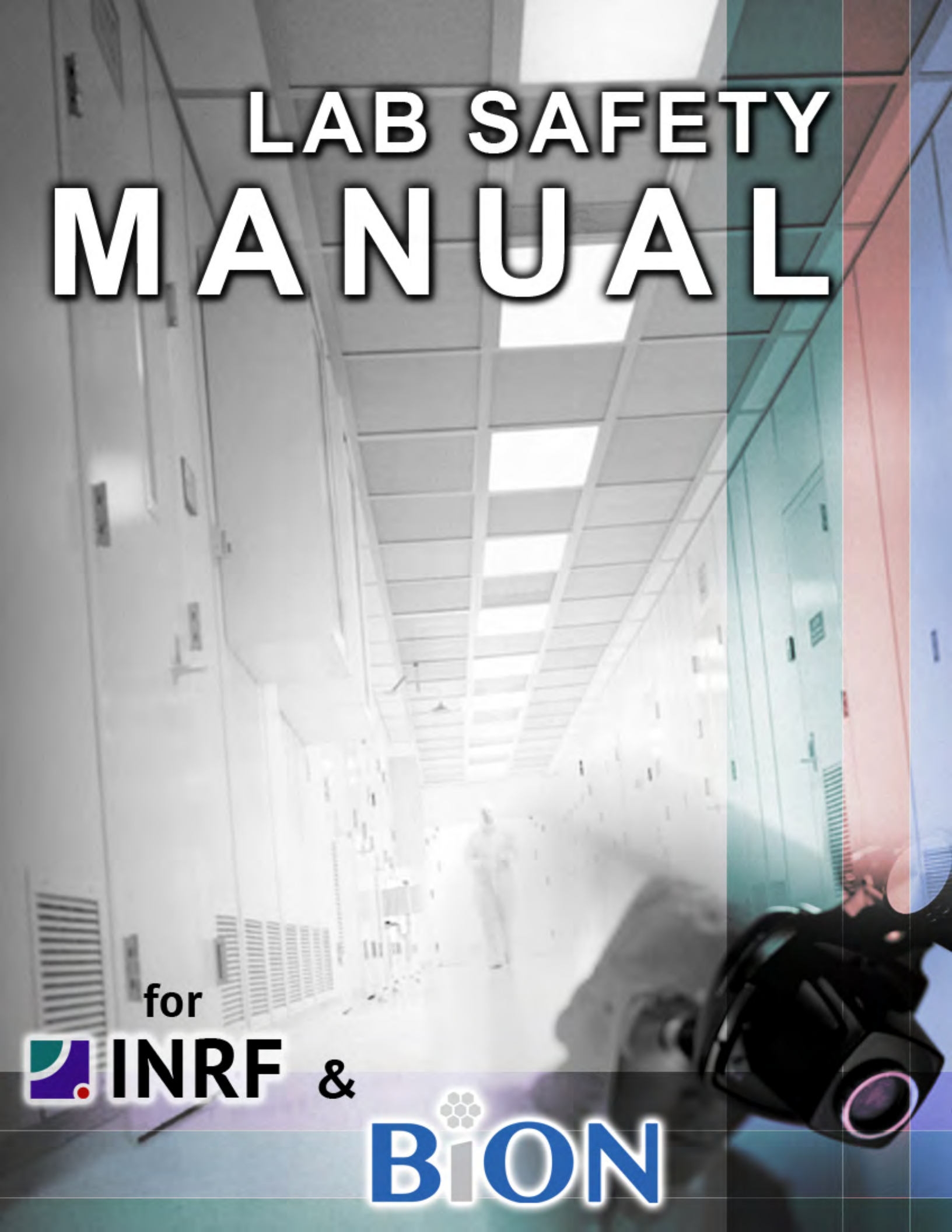
LAB SAFETY MANUAL



for

INRF &

BiON

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1. Safety Philosophy

The UCI INRF and BiON Facilities are committed to safe and responsible research. We take great efforts to make our facility one of the safest laboratories on campus. We use engineering safety controls on all our equipment and utilities, monitor equipment regularly, and conform to all UCI and California regulations for safety and environmental health in a research environment. We encourage an open dialog between users and staff to ensure the facility is a safe and pleasant place to work in.

The primary goal of this safety manual is to prevent accidents. This can best be achieved if each person in the lab understands potential safety hazards, and observes the appropriate safety precautions for the particular tool used. However, it is understood that no system is perfect, and accidents **WILL** happen. Thus, the secondary goal of this safety manual is to minimize the effect of an accident by educating users to know how to respond in emergency situations.

1.1 INRF/BiON Responsibility

With regard to laboratory safety, the responsibility of INRF/BiON is to:

1. Educate and inform user of the potential safety hazards and appropriate response procedures in the lab
2. Provide the appropriate tools and resources to use the lab safely.

Communicate INRF/ BiON Safety Hazards through:

1. Lab Safety Manual
2. The New User Orientation
3. The INRF and BiON Safety Assessment
4. The INRF Chemical Hygiene Plan
5. UCI EH&S Online Safety Training
6. Standard Operating Procedures for Equipment

The resources provided by INRF/BiON to users include (but are not limited to): the MSDS sheets provided near the entrance gowning area and on the website; **http://www.inrf.uci.edu/safety/standard-procedures/** operating procedures and training in safe operation for each tool; Protective gear appropriate for laboratory processing and training in its use; documented and posted procedures for actions to take in an emergency situation; knowledgeable personnel, trained in safety and emergency procedures.

1.2 User Responsibility

Your responsibility as an INRF/BiON user is to:

1. Study this lab safety manual and other safety resources provided by our facility and EH&S
2. Log in prior to entering the facility so we can maintain a headcount in case of an emergency.
3. Log in at various tools and enter the data into log books so we can maintain a history of materials being used.
4. Clean up after yourself and behave in a safe, conscientious, and professional manner in all lab activities.
5. Safely dispose of chemical waste (see section 5.4)
6. Be conscious of potential safety hazards in the lab and take appropriate precautions to limit risk and exposure to these hazards while working.

The INRF/BiON provides you with information and tools to use the lab safely; however, it is incumbent upon each individual to take responsibility for his/her own personal safety. Moreover, as the INRF/BiON is also a community, each researcher is responsible for the safety of his/her fellow researchers. Anyone found behaving irresponsibly to the extent of endangering others may be denied access to the labs at the discretion of the INRF/BiON staff.

The staff at INRF/BiON also recognizes that in this research environment, users need to test and develop new tools and process capabilities. The researcher's responsibility, in these cases, is to work with staff to ensure that any new procedure/chemical/equipment be introduced in a safe manner.

It is also your responsibility to report any safety concerns you may have to each other and to INRF/BiON staff. To report any potentially unsafe conditions or practices, or to offer suggestions for improving safety, direct an email to safety@INRF.uci.edu

2. General Safety

2.1 Lab Behavior

To avoid collisions with others open doors slowly and approach corners and turns slowly. Always remember that researchers around you may be handling sensitive materials such as chemicals, or their years' worth of work.

Minimize clutter and always clean up after yourself – remove or store everything that you've brought into the lab with you. Label all personal belongings with your name, so that they may be returned to you if misplaced. Always try to be aware of your work area and be sensitive to what other researchers are doing around you.

The following activities are **prohibited**:

1. Eating and gum chewing
2. Bringing in drinks, including water bottles (please use water dispenser outside the lab).
3. Sudden and fast movements (i.e., no running).
4. Wearing open toe shoes or sandals
5. Working alone when handling hazardous material (see section 2.5)
6. Bringing in chemicals before receiving proper approval (see section 5.2 and 5.5)
7. Working with chemicals in an undesignated area (must work under exhaust hood)
8. Installing or changing out gas cylinders

2.2 Clothing

Shoes worn in the lab must fully enclose the feet to minimize tripping hazards (absolutely no sandals, open toes, or sling-back shoes). This is the only clothing restriction in the lab. Since you will be wearing a bunny suit over your normal clothing, we recommend that your clothes should be light, comfortable and allow free movement. Bare legs (i.e. wearing shorts and dresses) are not recommended; slacks are preferred as they provide additional protection to legs.

2.3 Eye Protection

Safety glasses should be worn at all times in the lab, except perhaps when using a microscope or other equipment with eyepieces. Safety glasses must be ANSI Z87.1 approved (with side shields or other side protection) with " Z87" stamped on the spectacle frames/temples. For researchers requiring corrective lenses impact-resistant prescription safety glasses with side shields can be purchased from most prescription glasses suppliers. Most safety glasses are designed to protect only against flying fragments, however, not chemical splash hazards. So full face shields should be worn in addition to glasses when handling chemicals or working at chemical wet benches. Chemical splash goggles are recommended where there's a potential for splashing.

Regarding the use of contact lenses, the INRF/BiON abides by the American Chemical Safety Society recommendation that "contact lenses can be worn in most work environments provided the same approved eye protection is worn as required of other workers in the area". (C&E News, Vol. 763, p. 6.) Thus, contact lens

wearers must use standard safety glasses when working in the lab, and full face shields in addition to safety glasses when working at chemical wet benches.

2.4 Protective Gear

While operating certain stations, additional protective wear will be required. Use of any wet benches or the normal handling or transportation of any chemicals in the lab requires the use of protective chemical wear. See the SOP and the chemical handling procedures in the appendices for specific details. Certain process and maintenance functions may require additional gears, such as respirators; however, researchers should not be required or asked to perform such functions.

2.5 Buddy System

For safety reasons, a user is not allowed to work in the lab alone at any time when using hazardous material. Because the lab runs 24/7, there may be occasions (such as a late night, over a long holiday or weekend) when you plan to work during a time when there is no staff. However, you may only access the lab as a super user and do limited research. If you are not a super user you must plan ahead and coordinate your work schedule with staff or a super user. In all cases, you must inform staff if you plan to use the INRF/BiON facilities during off hours.

2.6 Special Health Considerations

- **Pacemakers**

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

- **Reproductive Health**

Users who express a concern about their reproductive health potentially being affected by the work area should notify their supervisor and the INRF/BiON Safety Officer and EH&S to initiate a worksite evaluation.

- **Chemical and Latex Allergies**

The trace presence of certain chemical compounds in the lab may trigger allergies in certain sensitive individuals. The most common chemical sensitivity encountered is that to latex, found in the clean room gloves. Nitrile cleanroom gloves are provided and may be used in place of latex, by sensitive individuals. There may be other trace chemicals present in the lab, which may also trigger allergies, Learn to recognize the signs of contact allergic reaction (skin sensitivity, hives, wheezing) and act to identify and avoid future contact.

3. Laboratory Hazards Overview

3.1 Chemical Hazards

Every chemical is hazardous, even water, it depends on dose. We handle hazardous chemicals in our every day lives, from pumping gasoline to using chlorine bleach. The keys to safe use of these and any chemical are: understanding the hazards presented by each specific chemical; knowing and using the appropriate precautionary measures to minimize these hazards.

Despite the many hazardous chemicals present in the lab, the INRF/BiON has a good safety record. However, because of this, it is also easy to become complacent and treat hazardous materials casually. The importance of precautionary measures cannot be emphasized enough. Simple precautions can be a lifesaver; use them as you would a safety belt in a car.

- ***Gas Hazards***

Compressed gases pose both chemical and physical hazards. Some of the gases used at INRF/BiON are considered inert; others fall into the categories of toxic, corrosive, flammable, or explosive. The primary health risks posed by gases are the physical hazards (fire, explosion) and inhalation (toxics and corrosives.) General information about some of the common gases used at INRF/BiON can be found in section 8 (for more detailed hazard information, please refer to the pertinent MSDS.) Because of these potential hazards, safe use of these gases is strictly determined by state and local regulations, and university policy. Although potential hazard are minimized by use of engineering controls and the toxic gas monitoring system (see section 7 on toxic gas safety), as a researchers you must still be always aware of the types of gases and the hazards posed by the equipment you operate.

- **Liquid Chemical Hazards**

These present the greatest risk for injury, for several reasons. First, extensive handling (transporting, pouring, and mixing) is generally required for use in the lab**.** Second, there are many liquid chemicals used throughout the lab, each with a different set of hazards and precautionary measures required for use. Third, unconventional uses of standard chemicals (i.e., mixing or heating chemicals, etching of non-standard films, etc.) can present unexpected hazards not associated with their normal use in the lab. Chemicals commonly used in the lab can cause severe burns, tissue, and organ damage, and can ignite and explode**.** The greatest health risks posed by liquid chemicals are physical (fire, explosion), direct contact with skin and eyes (tissue damage), and inhalation (pulmonary damage or long term chronic effects). General information about some of these chemicals and their uses can be found in sections 5 and 6. For more detailed hazard information, consult the pertinent MSDS. Make every effort to understand the chemical processes you use and respect the chemicals you work with. Knowing the general rules for how to safely transport, pour, use, and dispose of these chemicals is every researcher's responsibility**.**

3.2 Electrical Hazards

The danger of injury due to electrical shock is present wherever electricity is used. Although most equipment is interlocked to prevent exposing operators to electrical hazards, you must be acquainted with the electrical hazards, which may be encountered for the tool you are using.

The primary effects of electric shock are due to current flowing through the body. Burns occur wherever the body completes a circuit connecting the power source with ground. Although the resistance of dry, unbroken skin to electric current is relatively high, the amount of current needed to kill a person is small. It is easy to exceed lethal levels of current, especially if the skin is broken, wet, or damp with sweat.

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

With the exception of most personal electronics devices, any electrical equipment brought into the lab must have prior approval by an INRF/BiON staff member. The job of the staff member is to ensure that you will be able to use the equipment in a manner that is safe and consistent with INFR/BiON laboratory policies. Personal electronics devices that do **NOT** require staff approval include: laptops, cell phones, and PDA's. The only personal electronic devices **that are NOT allowed in the lab are personal listening devices (iPods and such)** as these may prevent the user from hearing alarms or lab announcements.

3.3 Other Hazards

Many tools in the lab use or generate high voltages, ultraviolet, or electromagnetic radiation. Safety interlocks are built into each tool, which prevent direct high voltage sources or exposure to radiation sources during normal operation. However, no system is absolutely foolproof. It is absolutely essential that you, as a researcher, learn and are always aware of the potential hazards, and follow the procedures for safe operation of each tool you are qualified to use.

- ***Ultraviolet Radiation***

Chance of exposure is clearly a risk in lithography, where high power UV lamps are used in the aligner and stepper tools. However, UV exposure is also a potential risk in plasma etch, plasma deposition, and sputter tools, where highly energized species are generated.

- ***Electromagnetic Radiation***

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

- ***Cryogenic Hazards***

Cryogenic hazards are presented by liquid nitrogen ("LN2"), which is used in many areas of the lab, such as cryo pumps. Liquid nitrogen is 77 °K (196 °C below freezing) and can thus cause freezing burns. Do not handle liquid nitrogen unless your equipment training covers it. Always wear protective gear (thermally insulated gloves and goggles) when handling liquid nitrogen.

4. Where to find Chemical Safety Information

4.1 Chemical Labels

Each chemical storage container is required to have a label, provided by the manufacturer, which in addition to composition; it contains the following precautionary information:

1. "Caution", "Warning" or "Danger", indicating an increase risk for potential hazard.
2. One or more Statements of Hazard, which describe in more detail the hazard presented.
3. Precautionary Measures
4. First Aid or other information (this may not always be present on the label).

Remember, only chemicals in their original containers will have these labels. Chemicals that have been dispensed for use or into other containers may not have this information. Since gases are supplied remotely, their label information will not be handy. As a qualified user, it is your responsibility to know the chemicals being used at your station, and the hazards posed by each.

4.2 MSDS

Chemical manufacturers and distributors are required by federal law to provide safety information for each product they sell. The Materials Safety Data Sheet (MSDS) contains information on general composition,

physical and chemical properties, toxicology, and storage and handling recommendations of each product. MSDS documents for most of the chemicals that INRF/BiON routinely stock can be found in the lab office area and in the gowning room. Researchers wanting to bring in any new chemical or chemical mixture, for use in the lab must provide an MSDS as part of the new materials approval process (see sec 5.5 Bringing New Chemicals)

MSDS information for many chemicals/chemical mixtures is also available on the web. The UCI Environmental Health and Safety group (EH&S) maintains a website with MSDS information for chemicals used at UCI. Major suppliers also provide information on their products, usually free of charge. Links to the UCI and other sources for MSDS information can be found on the INRF/BiON **website, under MSDS**.

It is highly recommended that you read the MSDS information for all the chemicals that you use in the lab. With that being said, we at INRF/BiON recognize that MSDS information can be difficult to read, as it is directed to safety personnel, without specific regard to our applications in microfabrication. So, the staff also makes every effort to provide application-specific, chemical hazard information in operating procedures and on the website. You will be expected to know the main hazards, handling requirements, and disposal methods for any chemical you use in the lab.

4.3 UCI, EH&S and INRF/BiON Websites

The UCI Environmental Health and Safety (EH&S) department maintains an extensive website library on chemical safety. Included in the library is educational material on safety basics, such as how to decipher the terminology in an MSDS form. The UCI EH&S website is located at: **www.ehs.uci.edu/msds.html**

The INRF/BiON website contains information about chemicals and their specific use in the lab. The Materials and Safety sections of the website includes: links to MSDS sheets, lists of acceptable materials in the lab, and procedures for safely bringing in new chemicals and new processes. The website contains links to Operating Procedures for each equipment which includes safety information for the chemicals and other hazards at each station. The Processes section of the website includes much information about the standard use of many of the common chemicals found in the lab.
www.inrf.uci.edu/cleanlog/default.asp

If you do not find the information you require on the website, please consult with any member of the staff. If you have information you would like to share with others, please forward it to any staff member for posting on the INRF/BiON website.

5. Liquid Chemicals

5.1 INRF/BiON Chemical Hazard Classes

At INRF/BiON, we categorize liquid chemical hazards into six general chemical hazard classes: corrosive, oxidizer, air/water reactive, flammable, toxic/poison, and non-toxic. Many chemicals fall into more than one class. It is essential that you recognize the chemical hazard class of al the chemicals you are using and understand the appropriate general precautionary measures required for safe use. The following are the usual safety measures for handling any liquid chemical:

1. Know the main hazards and proper disposal method of the chemical you are using.
2. Use protective gear (safety goggles and face shield, tested and resistant gloves, chemical apron) to prevent direct contact with the chemical.
3. Work only in an appropriately exhausted hood area to prevent inhalation.
4. Know the location of the nearest safety shower and eyewash station.

- ***Corrosive***

A corrosive (or “caustic”) chemical destroys or permanently damages living tissue. On contact, corrosives can destroy skin and underlying tissues. Splashes in the eyes can cause blindness. Inhalation of vapors can destroy

lung tissue. Corrosives in the lab include acids and bases. In case of localized external exposure, promptly flush the affected area with plenty of water, for at least 15 minutes. For more general external exposure, use a safety shower. Remove clothing while under the shower and flush for at least 15 minutes. Exposure of corrosives to the eyes is extremely serious; flush immediately, either with a spray gun at your wet bench or the nearest eyewash station. Eyes should be rolled up and down, and side to side, continuously, to allow clean water to flush behind the eyeball. For any exposure to corrosives, you should get help. The victim should be taken to the emergency center for evaluation and treatment.

- ***Oxidizer***

Technically, an oxidizer is a chemical compound that has a pair of electrons to donate to an electron-accepting, reducing agent. Very often, oxidizers are chemical compounds that contain a reactive oxygen component. When mixed with compounds that can act as reducing agents, the result is often a violent reaction, possibly an explosion. Oxidizers should not be stored or mixed with solvents, which generally make excellent reducing agents. At UCI, oxidizers are stored in the chemicals storage cabinet. The most commonly noted example in the lab of an oxidizer is hydrogen peroxide. However, other compounds, such as acetic acid and nitric acid, are oxidizers as well as corrosives.

- ***Water Reactive***

Water reactive is used to describe compounds (generally concentrated acids and bases), which very quickly generate heat and/or gas upon mixing with water. The primary hazard presented by water-reactive mixtures should NEVER be poured directly into a sink drain. Aspirating water reactive mixtures is safe; the high dilution factor and rapid mixing dissipates heat and prevents superheating. Do not aspirate chemicals without first consulting with INRF staff and EH&S.

- ***Flammable***

These compounds include most solvents, such as acetone, isopropanol, and methanol. In air, above a critical concentration, called the “flash point”, the vapors from a flammable can ignite and explode. The source of ignition may be heat (such as a hot plate) or a spark (such as from an electrical tool or static). Because the vapors can travel over considerable distances, the source of ignition can be far away from the flammables container itself.

To minimize hazards, always work well within the exhausted area of the appropriate bench. The air pulled into the exhaust area will keep the concentration of vapors below the flash point. Where possible, minimize the quantities of flammables used. Before working with flammables, always note the location of the nearest safety shower and fire extinguisher. Flammables should be stored in the designated flammables cabinet; no flammables may be stored outside flammable cabinet.

- ***Toxic/Poison***

A toxic material is one that has poisonous or harmful effects. There are formal, qualifiable definitions as to what comprises a toxic material and to what degree it is toxic. These definitions are based on lethal dosages for lab animals when administered orally or through inhalation.

- ***Non-Toxic***

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

5.2 Liquid Chemical Storage

To prevent accidental mixing of incompatible materials, every chemical in the lab must be stored in the designated area appropriate for its hazard class. Each storage area is designed for safe storage of chemicals of a particular set of hazard classes (i.e., they are appropriately ventilated, chemically resistant, and built against the main physical hazards presented by the chemicals to be stored there.) Thus, it is a safety imperative that all chemicals in the lab be stored appropriately in one of these designated storage areas. **NO chemicals may be kept in the personal storage cabinets**. Chemicals may be stored at wet benches if approved.

The designated Chemical storage area in the lab is:

Location	General Hazard Class	Chemical Type	Processing Use
Chemicals under Polypropylene wet bench	Corrosives, oxidizers	Acids, bases, oxidizers, separated By compartments	Etchants
Flammables cabinet	Flammables	Solvents, bases Organics	Resists, developers, solvents
Refrigerator	Flammables	Hydrogen Peroxide SU-8,	Temp sensitive resists

- ***General use chemical storage***

The INRF/BiON staff keeps virgin chemicals stocked in the areas listed in the table above. Please consider your safety and that of others when using these chemicals.

- Follow appropriate procedures for handling and transporting chemicals in the lab (see Appendix). You must be trained and qualified in use of wet benches before working with chemicals.
- When you return chemicals, the outside of the bottles must be clean and dry.
- Containers that are already opened should be used first.
- Notify INRF/BiON staff when chemicals are running low (particularly important before a weekend!).

- ***Personal chemical storage***

Researchers may keep personal containers of chemicals, but with the following restrictions:

- The chemical must be approved for use in the lab (if not already approved).
- It must be acceptable for the process for which you plan to use it.
- It must be stored in the designated personal storage area for the appropriate hazard class (adjacent to general use storage). No chemicals may be stored in personal cabinet.
- Personal containers, even if they have the original manufacturer's label, must have the official yellow hazardous materials label. These are available from INRF/BiON process staff members, who will confirm with you the proper handling and storage procedures for your chemical. The information required on the label includes:
  - ⇒ Your contact information
  - ⇒ The main hazard group (corrosive, flammable, oxidizer, reactive, toxic/poison, non-toxic).
  - ⇒ Chemical Storage Group identifier, (see the UCI Chemical Safety Database and the UCI website) is denoted by a single letter.
  - ⇒ Exact name(s) of the chemical.
  - ⇒ Date chemical was received.

- You are responsible for the cost of removal or disposing of nonstandard chemical when it is no longer needed.
- Make sure your containers are compatible with the chemical mixture. To verify container compatibility visit: http://www.coleparmer.com/Chemical-Resistance

As a research lab we understand that researchers will always need to test, characterize, and use new chemicals. However, since we are a shared resource, the actions of any individual can significantly affect the work of others. Thus, it is absolutely essential that every researcher be conscientious about handling of personal chemicals.

5.3 Working with Liquid Chemicals at the Wet Benches

Chemicals may be used only at exhausted wet benches. (The exception is the limited use of squeeze or spray bottles containing mild solvents for cleaning; see below). Wet benches are designed for the safe use of chemicals; only designated chemicals or classes of chemicals may be used at each wet station. Every wet bench has perforated deck to allow efficient amount of exhaust. **DOT NOT** block or cover these holes, this will allow you to have a safe work surface area to use chemicals. All handling of chemicals must take place under exhaust hoods. There are two general types of wet benches in the lab: those used for "Standard" processing and those used for "Non-standard" processing. To use a wet bench, you must be trained and qualified in its safe use.

➢ ***"Standard" exhausted wet benches***

They must be used only for standard processes and chemicals, as described in the operating procedures for each station. Although very limited, non-standard processing may be accommodated at these benches, any non-standard chemical or procedure requires advance authorization from INRF/BiON staff.

Standard wet benches are designed to handle whole cassettes of wafers and have a range of semi-automated modules (hot pots, wet tanks, dump rinsers) for processing cassettes. Each *standard wet bench* has dedicated lab ware, in order to avoid cross-contamination (do not use lab ware from one bench to another bench).

Because designated process modules are used at *standard wet benches*, no beakers or other chemical containers may be used for processing at *standard wet benches* (no Hazardous In-Use forms should be used at any *standard wet bench*). By standardizing chemical usage at these Standard benches, we can ensure predictable, and therefore safe, processing at these stations.

➢ ***"Non-Standard" exhausted wet benches***

Wet benches: are manual stations and can be used for a broader range of chemicals, within the limits of what is considered chemically compatible for each station. Beakers and other chemical containers may be used at these stations, but only if accompanied by the information needed to identify what the container contains. Blank forms are available at each *Non-standard wet bench* and in the gowning room area. The information required on the Hazardous In-Use form is as follows:

- Date
- Your contact information (name, phone, login)
- Name of the chemical (no acronyms or abbreviations, please)
- Hazard Category

Use of the Hazardous In-Use forms is strictly enforced; failure to abide by this is considered a gross violation of UCI safety policy and will be dealt with accordingly. Please remember, this is a shared facility and communication of lab activities that pose potential safety concerns is absolutely critical.

➢ ***Squeeze or spray bottles***

Bottles containing mild solvents (acetone, isopropanol, or methanol) are the only chemicals that may be used outside of the wet benches. They still should, however, be stored at the wet benches, and they must be properly labeled. They should be used only very sparingly outside of wet benches, because of their low vapor pressure, and they should be mostly be used at solvent wet benches not near any electrical equipment.

➢ ***Protective Gear (PPE)***

Protective gear is required whenever handling or transporting chemicals in the lab. The degree of protective gear depends on the chemicals being used and where they are being used. The table below lists the type of protective gear that is generally used for various chemical types. This table should serve only as a guideline; the operating procedures for each wet bench should serve as the final word.

Chemical type	**Recommended protective gear**
Corrosives or Oxidizers	face shield, apron, test chemically-resistant gloves
Solvents	tested chemically-resistant gloves
Photoresists or developers	nitrile gloves *

For researchers concerned about chemical exposures, contact INRF/BION Safety Officer or EH&S for further evaluation.

Remember, **you are responsible for your own safety, and that of others around you.** UCI provides you with information, recommendations, and necessary resources for you to be able to do our work safely. It is up to you to ensure that you take appropriate precautions for your safety and your fellow researchers.

➢ ***Transporting chemicals in the Lab***

Chemicals should be transported using the appropriate transfer carts (white polypropylene for corrosives/oxidizers; metal for solvents/resists/developers.) Chemicals must not be carried by hand; unless a covered, chemical bottle carrier (available in the stockroom) is used. For specific procedures on transporting chemicals in the lab, see the Appendix.

➢ ***Mixing and/or Heat Chemicals***

Chemicals can behave very differently when heated or mixed with other chemicals and present completely different risks. You are performing a non-standard process, if you are heating a chemical, which is not normally heated or mixing chemicals that are not normally mixed even if the chemicals are normally stocked in the lab. The following hazard classes should not be mixed together:

Corrosives + Flammables = Explosion/fire
Corrosives + Poisons = Poison gas
Flammables + Oxidizers = Explosion/fire
Acids + Bases = Corrosive fumes/heat

➢ ***Chemically Resistant Labware***

When using any wet bench, the labware (cassettes, cassette holders, etc.) must be chemically compatible with the chemicals you are using. The *standard* wet benches have dedicated labware no other labware may be used at these benches and the labware at these benches may not be used anywhere else. The *nonstandard* benches may not have dedicated labware. It is your responsibility to ensure the labware you use will not react with, melt, or dissolve with the chemicals you are using at these benches.

5.4 Chemical Waste Disposal

Disposing of chemical waste in a safe manner is every researcher's responsibility. Improper disposal of waste could result in explosion and injury. Violations of proper waste disposal laws may even result in shutdown of our lab. Please take time to consider waste disposal in you experimental plans. And please remember that waste

disposal cost in California is high and everyone bears the economic and environmental burden; please try to minimize waste generated.

There are two ways of disposing of liquid chemical waste. The required method for disposal depends on the kind of chemical waste generated:

1. Local solvent collection tank;
2. Local bottle collection.

These are the five general kinds of liquid chemical waste, with different methods of disposal:

1. Standard inorganic acids and bases (local collection)
2. Fluorine-containing acid mixtures (local collection)
3. Solutions containing heavy metals (i.e. metal etchants) or other hazardous materials (local collection)
4. Standard solvents (solvent collection tank)
5. Halogenated solvents (local collection; where possible, separate from nonhalogenated solvents)

Details procedures on how to dispose of chemical waste are found in the standard operating procedures for the specific chemical processing wet benches. A general description of the chemical waste disposal systems and methods follows.

The Acid Waste Collection – Standard inorganic acids and bases are collected at the individual acid wet benches in labeled collection bottles (see SOP for)

HF Waste Collection – High concentrations of fluorine ions are an extreme health hazard. Therefore, fluoride-ion-containing solutions must be disposed of separately from other waste, using the HF approved containers. These solutions include hydrofluoric acid, buffered oxide etchants (BOE's) ammonium fluoride, and any mixtures thereof. Waste from the HF containers is collected and relocated outside the lab, and is regularly removed for disposal by a local service provider.

Standard wet benches and at non-standard processing wet benches HF and BOE waste must be manually poured into the specially marked HF approved containers. These mixtures must NOT be aspirated nor poured down any other drains. If this is done accidentally, notify a lab staff member immediately.

Solvent Waste Collection Containers – Standard, non-halogenated solvent waste is collected into containers at the solvent wet benches. The standard solvents are: methanol, isopropanol, and acetone. Standard solvent waste includes these chemicals and associated photoresist waste. Do not put halogenated, organic waste into the Solvent waste collection container. (See below).

Local Collection – All chemicals used at INRF/BiON are disposed of using general waste collection containers or bottle and are finally disposed through EH&S. Halogenated organic solvents pose special health and environmental risks for disposal, and so, must be collected, located, and separated from other kinds of waste. (Halogens are: chlorine, fluorine, bromine, iodine, and astatine.) The inorganic acids, such as hydrochloric acid, hydrogen fluoride or hydrofluoric acid, are not included in this category. Halogenated organics are discouraged from use in the lab and some are banned. Examples include chlorobenzene, TCE, borothene, and carbon tetrachloride.
Halogenated organic waste must be treated by incineration at higher temperatures than for other wastes, to prevent the possible formation of highly toxic compounds such as PCB's and dioxin. So please separate and properly label any halogenated waste from other solvent waste.

Any waste containing toxics, heavy metals, or any chemicals *must **NOT** be disposed of in the city waste treatment center and so must be collected locally. The most common source of metal ions in the lab is in used metal etchants (including gold and chrome etchants). These solutions must **absolutely not be aspirated or poured down any drain;** they must be collected in waste containers and sent out for hazardous waste disposal. Prohibited heavy metals and other toxics include, but are not limited to, the following:*

Antimony, Arsenic, Barium, Beryllium, Boron, Cobalt, Gold, Manganese, Molybdenum, Selenium, Thallium, Vanadium, Cyanide, Formaldehyde, Phenols, any chemicals on the Federal List of Acutely Hazardous Chemical or the California List of Extremely Hazardous Chemicals.

When in doubt about whether a chemical should be collected locally, check with the UCI staff. See the appendix for detailed procedures on local collection of chemical waste.

5.5 Bringing New Chemicals or New Processes:

By law, UCI is required to maintain an up-to-date list of the identities and amounts of all hazardous chemicals and materials in the entire lab. Violations jeopardize our ability to operate. In addition, with every new chemical/material brought into the lab, we need to ensure there is:

- A safe way and place to store it
- A safe way to use it
- A safe method of disposing of it and its byproducts
- A safe way to prevent cross-contamination of equipment groups

All process chemicals and materials used in the lab must be approved by the lab staff and user group Committee before use. New chemicals and materials are approved for a given process, on a case-by-case basis; use of chemicals/materials for another process will require a new committee approval. To register a new chemical, material, or process, please be prepared with the following information:

- Your name and full contact information
- Your PI (advisor) or Company
- The name of the new chemical (give all names commonly used)
- If there are secondary new chemicals that must be used with this material (such as a developer for a new resist) list each of them here and supply MSDS's for each of them.
- Complete manufacturer/vendor information including contact information
- A description of your plans for this new chemical/material/process (application notes and journal articles are very useful). You should have also checked to see if your chemical or something similar is already approved for use in the lab.

Personal-use chemicals must be appropriately labeled (with identification of owner, contents, and other safety info, as per section 6.2). As this is an ever-changing research environment, there is a vast number of chemicals and material, and we need your help to keep track of them all.

Because INRF/BiON is a community of researchers, we all need to be extremely considerate of potential problems posed by the hazards of new materials and how will they affect the research of others and, thus, the value of the lab as a research resource. The INRF and BiON staff should be able to answer most questions about which chemicals and materials can be brought in and where their use is acceptable in the labs. Please take time to carefully consider the process flow of your experiment and how it might affect other researchers and other downstream processes. Again if you have any concerns, contact the lab staff that will help you with your questions.

6. Specific Hazardous Liquid Chemicals

6.1 Solvents

Flammable solvents
Acetone, isopropanol, and methanol may be found at wet benches. Acetone is often used to dissolve photoresist and other polymer. Isopropanol and methanol are often used for cleaning.

These chemicals are all flammable solvents with low flash points. This means that at sufficiently high vapor concentrations, they can easily be ignited at room temperature and, therefore, pose significant fire hazard. Thus, solvents should not be used on or near hot plates, or near any electrical system. Solvents may also ignite or explode when brought into contact with chemical oxidizers (such as many acids) and should not be mixed with, nor collected in the same waste container with these compounds. Standard solvent waste should be disposed of in the solvent collection tank.

These and other solvents must be stored in the designated flammables cabinet with in lab and may be transported in the lab only to designated wet benches and hoods.

- ***Chlorinated Solvents***

Chlorinated solvents (such as chlorobenzene, and methylene chloride) may be present in some special resist processes, although these have largely been phased out of general use. Long term, repeated exposure to some chlorinated solvents is correlated to cancer and liver and nerve damage. Because of environmental hazards, chlorinated solvent waste must be collected in a waste container, separate from other kinds of liquid solvent waste.

- ***Glycol Ether Solvents***

Glycol ethers are solvents that may be present in some photoresists. These compounds have been implicated in reproductive problems, including possible miscarriages in semiconductor workers. INRF/BiON has phased out glycol ethers from the main line, standard photoresists. However some specialty photoresists used by some researchers may contain some glycol ethers.

Glycol ethers may be referred to generically as "Cellosolve", but the following names also refer to glycol ether compounds: Methyl Cellosolve, 2-methoxyethanol, Ethyl Cellosolve, 2-ethoxyethanol (2EE), Ethylene glycol mono ethyl ether. Acetate salts of glycol ether compounds may also appear in some specialty photoresist formulations as: Cellosolve Acetate, Ethyl cellosolve acetate (ECA), Ethylene glycol mono ethyl ether acetate, 2-Ethyoxy ethyl acetate.

Environmental monitoring studies done at UCI indicate that there is no risk of significant exposure of these compounds, as long as handling of photoresists takes place only in designated exhausted work areas. As a researcher, your responsibility is to always observe proper chemical handling practices, and to make sure that the people working around you also do so as well.

6.2 Oxidizers

- ***Peroxides***

All peroxides are highly oxidizing materials. Considerable energy is released when they are reacted. Some peroxides are unstable and can explode. 30% hydrogen peroxide in water is stocked in the lab. Extreme care should be used in mixing solutions containing peroxides. Peroxides are incompatible with all forms of organic solvents and flammable materials.

- ***Sulfuric acid and "Piranha" clean***

The heated mixture of concentrated sulfuric acid and 30% hydrogen peroxide is commonly referred to in the semiconductor industry as "Piranha clean". This mixture is an extremely aggressive oxidizer, used primarily for removing photoresist and, in sequence with other chemical mixtures, to remove contaminants (i.e., the "RCA" or pre-diffusion clean process). The proportions of sulfuric acid and hydrogen peroxide used will depend on the particular wet bench and application.
The piranha solution self-heats when mixed and immediately destroys organic materials it contacts (photoresist, clean room wipes, vinyl or latex gloves, skin). Piranha vapor is extremely caustic, so the piranha mix should be used only under an exhaust hood. Boiling piranha spatters, so always wear protective gear when working over a hot pot. Piranha is incompatible with all solvents and flammable materials. It reacts violently when mixed with base. Do not add water directly to piranha to try to cool it; sulfuric acid is water reactive, so adding water will cause heating (not cooling) and can lead to an explosion.

- ***Other Oxidizing Acids***

Nitric, acetic, and phosphoric acids are oxidizing acid that is also water reactive (their mixtures heat upon addition of water). Nitric and acetic acids are components of pre-mixed Aluminum etchants. Nitric acid is also a component of aqua regia. Heated phosphoric acid/water is used to wet etch silicon nitride. All oxidizers should be kept away from solvents, bases, and flammable materials.

6.3 Hydrofluoric Acid and Fluoride Containing Chemicals

Hydrofluoric acid (HF) and related fluoride-containing mixtures (such as ammonium fluoride or BOE) pose particularly dangerous health hazards. Concentrated HF produces extremely painful, deep tissue burns. Lower concentrations of HF are particularly insidious, as the initial contact may produce no pain at all, although tissue damage may continue over days following exposure. There are a lot of horror stories about HF. Take them seriously. For procedures on emergency treatment for HF exposure see section 9.10.

HF is a small molecule and a weak acid, so it can travel very quickly through skin and into tissues. Systemic damage can occur when fluoride becomes distributed throughout the body. Negative fluorine ions bind very readily to positive calcium and magnesium ions to form insoluble salts. This can result in severe electrolyte imbalance, including hypocalcaemia (loss of calcium) and hyperkalemia (too much potassium). Since calcium and potassium regulate the heart, irregular beating and cardiac arrest are manifestations. "Deaths have been reported from concentrated acid burns to as little as 2.5% BSA (body surface area exposed to skin contact)." (From eMedicine website.)

BOE's (buffered oxide etchants) and Pad Etchants are pre-mixed solutions of HF and buffer, or ammonium fluoride (NH4F). Although ammonium fluoride is a neutral salt of HF, it readily dissociates to yield fluorine ions, and so presents the same hazards as HF. All BOE's contain nearly the same total fluorine as concentrated 49%HF.

Calcium gluconate is used to treat exposure to HF. This compound provides extra calcium ions, which can scavenge free fluorine ions before they penetrate and damage tissue. In cases of skin contact, calcium gluconate gel must be applied immediately to the area of contact. In cases where systemic damage is a risk, calcium gluconate is administered by a healthcare professional, intravenously. Tubes of calcium gluconate gel, along with instructions for use are in the first aid kits in case of contact exposure, are mounted on the wall in front of the wet etch room where at bench there is usage of HF and fluorine containing chemical mixtures. More about emergency treatment of HF exposure can be found in section 9.10.

Pure hydrogen fluoride is an extremely toxic gas, which very easily dissolves in water. "Hydrofluoric acid" describes this solution form. HF easily passes between gas and liquid phases; so, HF – (and NH4F-) containing solutions will emit toxic fumes. Although UCI lab safety precautions tend to emphasize protection against skin contact with fluoride-containing solutions, remember to avoid inhalation of the fumes by always working under fully exhausted areas of the wet benches.

6.4 Alkali/Bases

Alkaline compounds, or bases, are the chemical opposite of acids, and may react violently when mixed with them. They are most commonly used in the lab in lithography and etch. Alkalis are caustic, so protective gear should always be worn when working with them to prevent contact with skin and eyes.

- ***KOH and TMAH Etchants***

Heated solutions of potassium hydroxide (KOH) or tetra methyl ammonium hydroxide (TMAH) are commonly used to chemically etch silicon. These etchants may be used only at the polypropylene wet station.

- ***TMAH***

TMAH and related bases make up most (but not all) of the resist developer chemicals used in photolithography.

- ***Removers and strippers (SVC 127, PRS 1000, and related chemicals)***

These are organic base mixtures, which are used for removing photoresist from wafers containing metal films (which are corroded by conventional piranha clean). Unlike other acids and bases used in the lab, these strippers are not water-based and are flammable; by some criteria, they may be considered solvents. Although these are treated as bases in our lab, strippers must never be directly mixed with strong oxidizers.

6.5 Gallium Arsenide

Gallium arsenide (GaAs) and its by-products are extremely toxic. All persons working with GaAs should develop especially good "housekeeping" habits and be constantly aware of how arsenic might be generated during processing. Avoid direct physical contact with GaAs and anything that comes into direct contact with GaAs. When breaking and scribing GaAs wafers, work under the designated bench with exhausted hood and wipe down all surfaces afterwards to prevent spreading of GaAs dust. Follow handling and decontamination procedures at each equipment where GaAs processing is done.

- ***Solid GaAs Waste***

Any GaAs waste, no matter how small, must be considered hazardous, including GaSa-contaminated labwipes and old proximity-cap silicon wafer. Place GaAs waste in an airtight zip-lock plastic bag and place in the "Solid GaSa Waste" can.

7 Hazardous Gases

7.1 Storage

Gases are stored by chemical class in individual gas cabinets and are monitored by an automated toxic gas detection system. Remote gases are delivered to the lab through a series of valves, regulators and flow control systems. Utility gases, such as nitrogen, are kept in liquid form in large storage tanks outside the lab. Few gas bottles like argon, and oxygen are stored in the lab; any that are in-use, must be secured (chained or bracket-mounted) to prevent getting knocked over.

7.2 Handling

There are extreme hazards presented in working with gas cylinders, so only trained and qualified staff may install, disconnect, or change out gas cylinders. Here are some of the risks involved with some of the gases at UCI.

- Gases, such as Fluorine/He and Nitrogen Dioxide, are extremely toxic. Small leaks may be fatal.
- Cylinder gases may be at pressures as high ad 3000psi. When punctured or cracked open, these cylinders may become rockets.
- Gas regulators are designed to handle specific gases. If not properly chosen and installed, leaks or explosion may result.

Improper installation and purging can result in contamination of the gas cylinder. This can damage materials processed with contaminated gas, and as some gases run in the thousands of dollars per cylinder, improper installation can also be very costly.

7.3 Toxic Gas Detection System

INRF has an automated toxic gas monitoring system consisting of remote sensors located throughout the lab and the equipment chases. Depending on the sensor, when triggered, the system launches a pre-configured sequence, which may include the following actions:

- Activation of gas shut-off valves
- Activation of visual alarms
- Activation of audible alarms
- Notification of the appropriate response teams

This automated function ensures the appropriate response will always be taken in the event of a toxic gas emergency and, thus, enables the lab to run 24 hours/day, 7 days/week. More information about the toxic gas alarm can be found in section 10.2.

8 Specific Hazardous Gases

8.1 Pyrophoric (flammable) Gases

These gases will spontaneously ignite in air within a critical concentration range.

- ***Silane (SiH4)***

It is used for deposition of polysilicon, amorphous silicon, nitride, oxide, and oxynitride films. It is a high-pressure gas. When exposed to trace amounts of air or moisture, silica dust can form.

- ***Dicholorsilane (SiH2CI2)***

It is used for deposition of polysilicon and amorphous silicon. It is low vapor pressure liquid source. Like silane, it will form dust when exposed to trace amounts of air and moisture.

8.2 Corrosive Gases

- ***Hydrochloric acid (HCI)***

HCI gas is extremely corrosive to almost everything, including stainless steel. HCI is used in the oxidation furnaces during steam cleaning.

- ***Ammonia (NH3)***

NH3 gas is a severely corrosive alkaline vapor with a pungent odor. It is shipped in the cylinder as a liquid under its own vapor pressure of approximately 9 atm. NH3 gas is used in oxynitride and nitride film deposition (plasma and CVD).

- ***Chlorine (Cl2)***

Cl2 gas is extremely corrosive, and can burn and damage eyes, skin, mucous membranes, and any other exposed tissue. It is shipped in the cylinder as a liquid under its own vapor pressure. The gas is used in REI systems.

- ***Boron Trichloride (BCl3)***

BLC3 is a toxic and corrosive and can burn and damage eyes, skin, mucous membranes, and any other exposed tissue. It is shipped in the cylinder as a liquid under its own vapor pressure. The gas is used in REI systems

8.3 Highly Toxic Gases

These gases described here are severe pulmonary irritants and acute systemic poisons. Overexposure can cause either sudden or delayed death due to lung destruction. Although each has a characteristic smell, the odor threshold is not much lower than the toxic exposure level. The gases here are used as dopants in CVD, epi, and implanter systems.

Xenon Difluoride (XeF2)

XeF2 is a **DANGEROUS!** Oxidizing, toxic, corrosive solid may ignite or explode on contact with combustible materials. Contact with water or moisture generates toxic fumes. It is corrosive to the skin, eyes, respiratory tract, and mucous membranes. Under ambient conditions, this is a white solid with an ozone-like odor.

Fluorine (5% He 95)

Fluorine is a **DANGEROUS!** (Pale yellow gas with a pungent, irritating odor) **DANGEROUS!** Oxidizer. May be fatal if inhaled, Causes severe respiratory tract, eyes and skin burns. Can cause target organ damage, Contact with combustible material may cause fire contents under pressure.

Nitrogen Dioxide (N02)

.Nitrogen Dioxide is a **DANGEROUS!** Poisonous, corrosive, oxidizing liquid and gas under pressure, and may be fatal if inhaled. Can cause severe lung damage, can cause eye and skin burns. Symptoms may be delayed. Vigorously accelerates combustion. Under ambient conditions, this is a reddish-brown gas with an irritating odor.

8.4 Non-toxic Gases

These gases are considered non-toxic because they do not generally pose an immediate risk to health and safety. However, they can be Asphyxiant and may pose other health risks at high concentrations or with long-term exposure.

- ***Nitrogen (N2) and Clean Dry Air (CDA)***

House nitrogen and clean dry air are plumbed throughout the labs for general use in equipment and other utilities. The supply can run up to 100 psi, which can pose a hazard: do not direct an N2 or air gun toward your own body (especially the face and eyes) or toward anyone else.

- ***Etch Gases***

SF6, CF4, O2, CHF3, C2CIF5, CBrF3, and C4f8 are commonly used in plasma etchers. Although the gases themselves generally pose low health risk, their by-products in etch systems are less benign. Make sure to follow proper operating procedures for pumping down or purging etch chamber systems following processing.

8.5 Cryogens

Nitrogen, are stored in liquid form outside the lab and are evaporated to be delivered to the lab in gas form. Liquid nitrogen (LN2) is also present in the lab as it is used in cold traps and cryopumps. LN2 should not be used in an enclosed space because of the risk of asphyxiation. LN2 can also burn tissue on contact, so protective gear must be used.

9. How to Respond in Emergencies

9.1 INRF/BiON Building Emergency Response Procedures

Emergency response procedures and emergency contact information for the INRF and BiON labs are posted throughout the lab and building (look for the Blue signs on the doors and by the phones.)

INRF/BiON Labs Emergency Response Procedures

Type of Emergency	Response
Health-threatening Emergency Requiring Evacuation (Fire, toxic spills, etc.)	• Pull fire alarm. • Evacuate immediately to the Assembly Point • Do not re-enter the building until cleared to do so.
Major Earthquake	• Take cover • After shaking stops, check nearby co- workers, and Evacuate to the Assembly Point
Life-threatening Medical Emergency	• Dial 911 immediately. Do not hang up until told to do so • Do not move victim unless necessary
Non-health threatening Emergency (Building and facilities)	• Call lab staff 4-2819 • If unavailable, call Facilities 4-5444 • After hours, call 4-5520
Electrical Power Outage	• Remain calm. Emergency backup lights should come on Within 15 seconds. • When emergency lights come on, leave the building from nearest exit • Notify lab staff Primary Contacts (563) 522-8328
Spill Cleanup Assistance	During normal working hours, call lab staff After hours, call EH&S (949) 824-5223and notify staff Primary Contacts (562) 522-8328

9.2 Building and lab Evacuations

Although UCI has a good safety record, the reality is that hazardous chemicals and other physical hazards are ever-present in the lab. In the case of an emergency, the priority is to ensure that everyone is safely away from these hazards. Depending on the extent and seriousness of the situation, an evacuation may be invoked just for the lab or for the entire building.

- ***Building Evacuation:***

When an emergency arises which requires the evacuation of the building, the fire alarm system will sound throughout the entire building. The fire alarm is automatically activated by smoke and fire detectors located throughout the facility and the building. The toxic gas detectors in the lab will only activate in case of a gas release not general fire alarm. The fire alarm can be activated manually as well as by pulling the handle at anyone of the pull stations located throughout the building.

When the fire alarm is activated, the alarm strobe will flash and a very loud klaxon will sound. When a fire alarm sounds, leave immediately. Do not take time to finish your tasks in the lab. Do not take time to remove your bunny suit or pick up your belongings. Leave the lab and the building through the nearest exit to the Evacuation assembly Point (EAP). Provide assistance to others as necessary. Provide information that may be of assistance to Emergency response personnel at the EAP. Only after the Fire or Police Departments declare the scene safe will you be allowed to re-enter the building.

Anyone in the building may call for an evacuation. This is an appropriate response to "an unforeseen event that calls for immediate action to protect individuals, the environment, or property". Examples of such situations include: fire, smoke, strong chemical vapors, or large chemical spill. To call an evacuation, pull the fire alarm. This will immediately notify the Fire Department and the appropriate UCI response teams.

All researchers should familiarize themselves with the location of lab and building exits, the Evacuation Assembly Point, fire alarm pull stations, and fire extinguishers.

*** Response Procedures:**

1. Evacuate immediately to the Evacuation Assembly Point (EAP)
2. Do not re-enter the building until cleared to do so

- ***Laboratory Evacuation:***

Some situations may warrant an evacuation of just the laboratory area, rather than the whole building. A lab evacuation may be invoked automatically or manually.

An automatic lab evacuation is activated by toxic gas alarms located in certain isolated, ventilated areas of the lab or support facilities. In the case of a localized toxic gas alarm, the red warning lights will flash and the alarm will sound only inside the lab. When in the lab you must leave immediately. Do not take time to finish your task in the lab. Do not take time to remove your bunny suit or pick up you belongings. Leave the lab through the nearest exit and assemble in the office area outside the lab.

*** Response Procedures:**

1. Evacuate immediately to the office area outside the lab
2. Do not re-enter the lab until cleared to do so

A laboratory evacuation should be manually invoked in hazardous situations which are isolated to the lab and do not pose a health or safety risk to building occupants outside the lab. Such situations include:

- Chemical spill
- Unusual odor

- Any other situation in which the health or safety of lab occupants may be of immediate concern

A laboratory evacuation is manually called by the staff. Anyone may call an evacuation. *Unless specifically otherwise instructed by a staff member*, you should respond as you would for a building evacuation. Leave immediately through the nearest lab exit; do not take time to finish your tasks in the lab, remove your bunny suit, or pick up your belongings. Meet in the office area outside the lab for further instructions.

* **Response Procedures:**

1. Take cover
2. After shaking stops, check nearby co-researchers and evacuate to the Assembly Point
3. Do not pull the fire alarm unless there is a health-threatening emergency

9.3 Major Earthquake

in a major earthquake, the greatest hazard you face while in the lab is falling objects (remember that there are laminar flow hoods above you in the lab) Toxic gases are not likely an immediate hazard, as the automatic shut-off valves will be activated under this condition. In the event of an earthquake, take cover in a doorway or under a solid table. After the earthquake, leave the lab and go to the designated assembly area.

* **Response Procedures**:

1. Take cover.
2. After shaking stop, check nearby co-workers, and evacuate to the Assembly area.
3. Do not pull the fire alarm unless there is a health-threatening emergency.

9.4 Life-threatening Medical Emergency

If a fellow researcher is experiencing a medical difficulty and cannot be easily escorted to the nearby medical service providers, you should call for emergency medical services. Dial 911 for the fire department. Follow any instructions the dispatcher gives (stay on the line until told otherwise).

Do not move the victim unless necessary. Moving an injured person can result in further or more serious injury. Do not touch the victim if you suspect electric shock.

* **Response Procedures:**

1. Dial 911 immediately. Do not hang up until told to do so.
2. Do not move victim unless necessary

9.5 Non-health Threatening Emergency

A non Health-Threatening Emergency is “an emergency in which there is not a clear potential for serious injury to any person. (If unsure whether an emergency is health-threatening or non health-threatening, assume it is health-threatening.)” This might include building and facilities problems such as a large water leak.

* **Response Procedures:**

1. Call lab staff ex 4-2819
2. If unavailable, call Building Facilities ex 4-5444
3. After hours, call primary UCI contacts ex 4-5520

9.6 Electrical Power Outage

* **Response Procedures:**

1. Remain calm. Emergency backup lights should come on within 15 seconds
2. When emergency lights come on, leave the building from the nearest exit
3. Notify lab primary contacts (562) 522-8328

9.7 Chemical Spills

Chemical spills that occur outside the ventilated area of a chemical wet bench can pose inhalation and contact hazards for other researchers. This is particularly unsafe if the chemical is a volatile, corrosive, or reactive material, if it is generating vapor or heat, or if the spill has occurred in or around electrical equipment. The response procedures to be taken will be determined by whether the spilled chemical which through evaporation or chemical reaction, is generating vapor or heat and thus poses a hazard to people in other parts of the lab. (Remember, you should always be familiar with the potential hazards of the chemicals that you work with!) Unless you are trained and specifically instructed by a staff member who has evaluated the situation, **DO NOT** make any attempt to clean up the spill yourself.

For non-vapor-generating, non-reactive chemical spills, and the hazard is confined to the immediate area. The priority is clear the immediate area and ensure that others do not enter the area.

* **Response Procedures:**

1. Clear the area
2. Block off the area using yellow "Hazard" tape
3. During normal work hours and on weekends, call EH&S 4-5730 and notify lab primary contacts (562) 522-8328
4. Provide as much information you can about the incident to the person responding

For chemical spills, which generate vapors or heat, there is a risk to the others in the lab at large; therefore, a laboratory evacuation must be performed.

* **Response Procedures:**

1. Clear the area
2. During normal weekday, working hours, call lab staff
3. Staff will go throw the lab announcing lab evacuation
4. After hours and on weekends, call EH&S 4-5730 and notify lab primary contacts 562 522-8328
5. Provide as much information as you can about the incident to the persons responding

9.8 Odors in the lab

With proper use of wet bench and disposal procedures, the laboratory should be free of odors. In general, if you smell something, there is either an equipment malfunction or someone has neglected to follow appropriate chemical handling procedures. However, on some occasions, the odor may originate from outside the lab (such as food in the office area or construction outside). If you smell something in the lab, notify a staff member right away. Provide as much information as you can about the location and possibly identity of the smell.

* **Response Procedures:**

1. Notify staff member
2. Clear affected area
3. Wait for instruction from staff, who will investigate

9.9 Chemical Exposure to Corrosives (other than HF)

Always, in case of exposure to corrosive chemicals, promptly flush the affected area with plenty of water. For non-HF containing solutions, flush for at least 15 minutes (for HF-containing solutions, see section 9.10

If the area of contact is small and on an extremity (i.e., hand), then a DI spray gun, DI tap, or even a dump rinse module at a wet bench, may serve if these are the closest sources of water. If the area of contact is large or on the body, you must immediately go to the nearest safety shower. Do not remove clothing; activate the shower and then remove all clothing under the shower. Continue flushing the affected areas with water for at least 15 minutes, while someone get help.

An exposure of corrosive to the eyes is very serious; because the eyeballs sit rather loosely in their sockets, a splashed chemical can work its way around the eye to damage the optic nerve. If chemical is splashed into an

eye, immediately begin flushing both eyes with water for at least 15 minutes. Both eyes should be held open with the thumb and forefinger. Victim should roll eyes up and down, and side to side, continuously, to allow clean water to wash away any corrosive that may have gotten behind the eyeball. While the victim is at the eyewash, someone else should be calling the doctor for further instructions.

For any exposure to corrosives, the victim should be taken to the emergency center for evaluation and treatment. If the corrosive contains HF, ammonium fluoride, or other fluorine ion containing solution, Follow the procedures in section 9.10

*** Response Procedures:**

1. Rinse affected area for at least 15 minutes. Remove clothing covering the affected area while flushing with water.
2. Call for help.
3. If mobile, the victim should be escorted to a local emergency medical provider (see section 9.13) for evaluation and treatment. If not call 911 for emergency medical help.
4. Following treatment, the injury must be reported to an INRF/BiON staff (see section 9.12)

9.10 Chemical Exposure to HF or Fluoride-ion Containing Solutions

Any exposure to HF or other Fluoride-ion containing solution must be treated immediately, as fluorine ions will quickly penetrate skin to damage tissue underneath. Chemicals stocked at INRF/BiON which contain fluorine ions include: **49% HF, 6:1 BOE, 20:1BOE, 50:1 BOE, concentrated ammonium fluoride, and PAD etch. Concentrated HF will immediately cause extremely painful burns on contact**. **However, more dilute HF solutions will not cause any pain; yet it can still cause considerable deep tissue or systemic damage.** If contact with HF (or related solution) is suspected, treat the incident as an incident as an HF exposure. Calcium gluconate gel is used as an antidote for HF exposure to skin. Tubes of calcium gluconate are located at main hallways in the lab along with instruction on its use. Calcium gluconate is for external use only and must not be used for chemical exposure to eyes.

*** Response Procedures:**

1. **IMMEDIATELY** rinse the affected skin area with lots of water. Being careful to wash the acid away from other part of your body, especially finger/toe nails where acid can get trapped.
1. Remove all clothing exposed to the HF. **Rapid decontamination is critical**.
2.
3. Continue rinsing for 1-2 minutes. Do not rinse for more than 5 minutes. Do not dry the skin.
4. Call for help.
5. Obtain Calcium Gluconate gel (available at all wet benches in the lab).
6. Puncture the tube using the inverted tube cap. Apply gel over the entire affected area.
7. Using gloves, gently massage the gel into the skin. Take the gel with you and continue to apply fresh gel while en route to the Emergency Room.
8. Elevate burned extremities, if possible.
9. Go immediately to a local emergency medical provider (see section 9.13).
10. Tell them you have Hydrofluoric Acid on you.
11. Continue to apply fresh gel (and gently massage it in) while waiting to be treated.
12. Following treatment, the injury must be reported to an INRF/BiON staff (see section 9.12).

9.11 Fire

Lab fires may result from the ignition of flammable chemicals and the combustion of materials. Ignition of chemical solutions on hot plates is a major cause of lab fires. When you are done working with them, Always be sure to turn off hot pots and hot plates. Always disable wet benches when you have finished working.

In the event of a small fire, if you have had fire extinguisher training you may use a fire extinguisher to put out the fire. Immediately report the fire to an INRF/BiON staff member (or notify UCI contacts after hours or call 911)

*** Response Procedures**

1. In the event of a large fire, pull the fire alarm or call 911 evacuate the lab.
2. If your clothes ignite, **DO NOT PANIC.** To extinguish the fire:
    a. Get under a safety shower; or
    b. Stop drop (to the floor), and roll

9.12 Reporting Accidents

All injuries must be reported to the EH&S and lab Management. Accident forms area available in labeled red folders, kept in the in the front office area or lab office. **See UCI Environmental Health and Safety UCI EMERGENCY PROCEDURES BLUE FLIP CHART** for information on how to report injuries, or see EH&S website: www.ehs.uci.edu/apps/hr/index.jsp

*** Accident/Incident/Exposure Form:**

This from must be submitted in the event of injury of any personnel, UCI or non-UCI. This form must be submitted to EH&S and lab Management within 24 hours of injury and signed by the injured party and an UCI staff personnel. This form is available online at: www.ehs.uci.edu/apps/hr/index.jsp

* **Employee's Claim for Workers' Compensation Benefits:**

This form must be submitted in the case of injury of UCI personnel. This form must be signed by a University representative/supervisor/administrator and then given or mailed to the employee within 24 hours of the accident, incident or exposure. The form and a detailed instruction sheet are available at: www.ehs.uci.edu/apps/hr/index.jsp

***Report of Serious Injury**

- Report all serious injuries **immediately** to EH&S. UCI must report any employee related serious injury, illness, or fatality, within 8 hours to an outside agency.

*** Employer's Report of Industrial Injury (Cal-OSHA Form)**

This from must be submitted within 24 hours of occurrence when an industrial injury or occupational disease suffered by a UCI employee results in

- Lost time beyond the day of injury, or
- Medical treatment by a physician in clinic, hospital, emergency room, or medical office.

*** A Workers' Compensation Lost Time Report**

Form must be submitted when a UCI employee has lost one full day or more following the day of an accident or the first day of a work related illness. Form is submitted online when the employee returns to work.

The form can be found at: www.ehs.uci.edu/apps/hr/index.jsp

9.13 Medical Providers for Work-Related Injuries

Unless you have completed a Pre-Designated physician form found at:
www.ehs.uci.edu/apps/hr/index.jsp

UCI University's medical providers for work related injuries are listed below.

*** For Non-Life Threatening Work-Related Injuries**

Follow the procedures below:
Campus: UCI Student Health during work hours and Newport Urgent Care off hours (walk-ins OK)
UCIMC: May see any UCI provider, consult the GSHIP program.
After hours: may see any UCI provider; call Referral Center 714-456-7890
Offsite location for after hours: UCIMC or as directed by referral center
For further information, contact 824-2388 or, see the GSHIP web site at: www.rgs.uci.edu/grad/students/gship/

- UCI Undergraduate students (non-employees)

ALL: Refer to Student Health Services on campus 824-5304
After Hours: Consult the Student Health services Website: http://www.shs.uci.edu/em,ergency.html.

- UCI Employees or Student Employees (both graduate and undergraduate)

During regular business hours: Contact workers Compensation 949-824-7008

1. Treatment may be provided at one of the following clinics by having your Supervisor or Department Administrator contact the clinic directly:
    - **Newport Urgent Care**, Newport Beach
      (949) 752-6300 (located off campus, map)
    - **Occupational Health Clinic**, Orange
      (714) 456-8300 (at UCI Medical Center, map)
    - **ProCare Work Injury Center**, Irvine
      (949) 752-1111 (located off campus, map)
    - **Kaiser Occupational Health Center**, Santa Ana
      (714) 830-6660 (located off campus, map)
    - **East Edinger Urgent Care**, Santa Ana
      (714) 541-8464 (located off campus, map)
    - **Occupational Services**, Long Beach
      (562) 933-0085 (located at Long Beach Memorial Hospital, map)

2. If you are unable to seek medical attention at one of these clinics, contact the Workers' Compensation Unit, at (949) 824-9152, for clinic referral.

In the event a Supervisor or Department Administrator is not available go directly to the clinic.

- **For Life-Threatening Emergency Care**

For immediate life threatening injuries **call 911**. If poisoning is suspected, contact the poison **Control Center at 800-222-1222.**

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10. Alarms

10.1 Fire Alarms

Appearance and location of the alarm beacons: Fire alarm beacons are located in the lab and throughout (both inside and outside). The beacon is a small rectangular white strobe, mounted in a bright red frame.

Alarm conditions: In an alarm situation, the beacon flashes with a very loud klaxon sound. In an alarm condition, all the alarms in the lab, Engineering Gateway and CaliT2 buildings should go off. The Toxic gases in the lab will be shut off immediately by staff and the O.C Fire Department will be on route.

Action to be taken under alarm conditions: Immediately evacuate the lab and the Engineering gateway and CaliT2 buildings to the designated evacuation point.

10.2 Hazardous Gas alarms

Appearance and location of the alarm beacons: The hazardous gas alarm beacons are located throughout the lab. The beacon is a large, flat round, green, yellow, and red wand indicators lamp, and are located in various rooms.

Alarm conditions and action to be taken: In an alarm condition, the beacon flashes with a very loud klaxon sound. There are two levels of alarms.

In a Level (1) alarm condition, the hazardous gas problem is isolated to a gas enclosure. In this case, only the alarm for that room will be activated. The room must be evacuated immediately, but the lab need not be.

In a Level (2) alarm condition, the hazardous gas problem might not be isolated in an enclosed area. In this case, the alarm beacons throughout the lab will be activated. The lab as well as the front office area must be evacuated to the designated assembly area. O.C Fire Department that will be called, automatically, will shoot off the hazardous gas in the lab.

10.3 Acid Waste Neutralization System

The INRF and BiON labs are not equipped with acid neutralization systems.

11. Lab and Building Maps (See Pages 10, 31, 32)

11.1 Lab and Building Evacuation Assembly Point

For any fire alarm and Level 2 hazardous gas alarm, all building inhabitants must immediately evacuate the lab, the Engineering Gateway and Calit2 buildings and go straight to the designated assembly area.

When evacuating, leave immediately; do not stop to remove your bunny suit or pickup your belongings. Leave the lab through the nearest marked “EXIT” door (remember: not all doors in the lab lead to the outside, so only use the marked ones!) Do not stop to save your work –your life is more important than a few wafers! And remember, any delay jeopardizes not only your personal safety, but also the safety of the emergency

response team members. On leaving the lab, continue out the building to the designated assembly area. Wait there for further instructions from a member of the emergency response team.

11.2 Equipment using Reactive gas

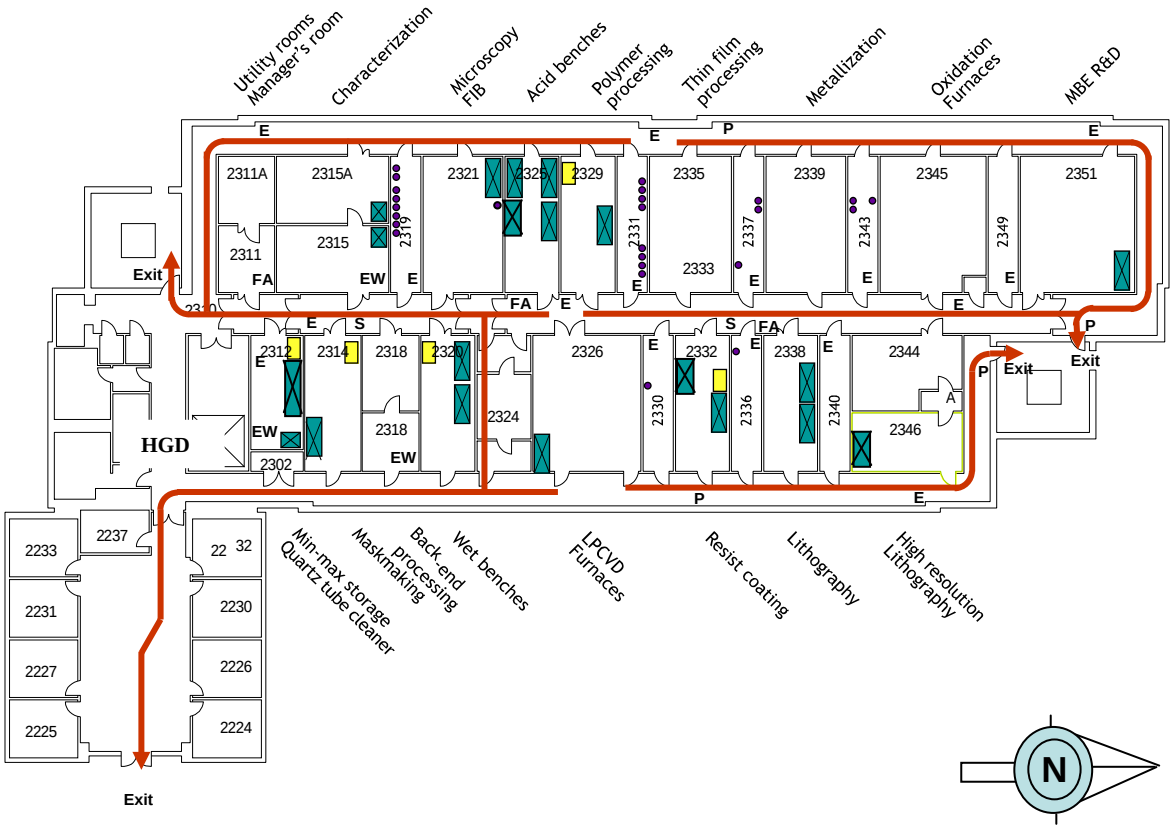
Prior to using the equipment verify the scrubber (CDO) is up and running and at temperature with no error messages.
Staff must charge equipment that requires reactive gases. Upon completion by researcher, staff will shut down or secure the gas source. If there is another scheduled user for that equipment the gases can remain on upon completion of work.
All reactive cylinders have identification tags, which display “in use” and “not in use”. Researchers can verify if the gases are on or off. At the end of each work day staff is required to evacuate the reactive gas lines.

11.3 Equipment lockout tag out

Lockout-tag out is a mechanism put in place to allow staff to perform maintenance or repairs on lab equipment or support equipment. These tags should not be removed by researchers, other than the specific staff member, that is presently working on that specific piece of equipment.
The majority of the lab equipment consists of multiple components, in some cases the system cannot be completely turned off.
Though the piece of equipment may appear up and running, staff could be performing maintenance or performing repairs. It is very important that researchers respect the lockout-tag out procedure

11.4 INRF Laboratory Safety Map

Integrated Nanosystems Research Facility

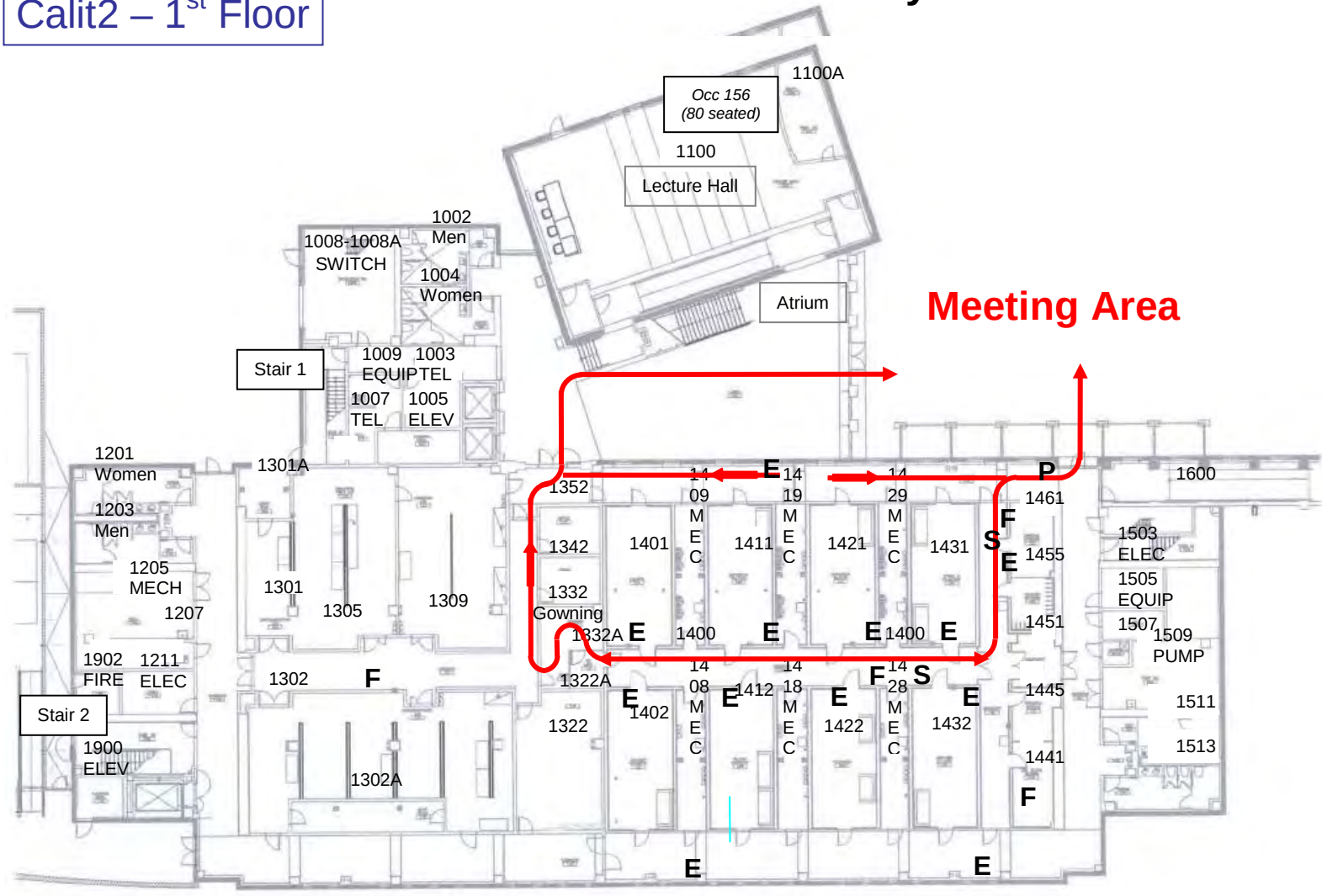


Fire Alarm Pull	**P**
Fire Extinguisher	**E**
Safety Shower	**S**
Eye Wash	**EW**
Evacuation Route	→
Hazardous Gas Detection System	**HGD**
First Aid Kits	**F**

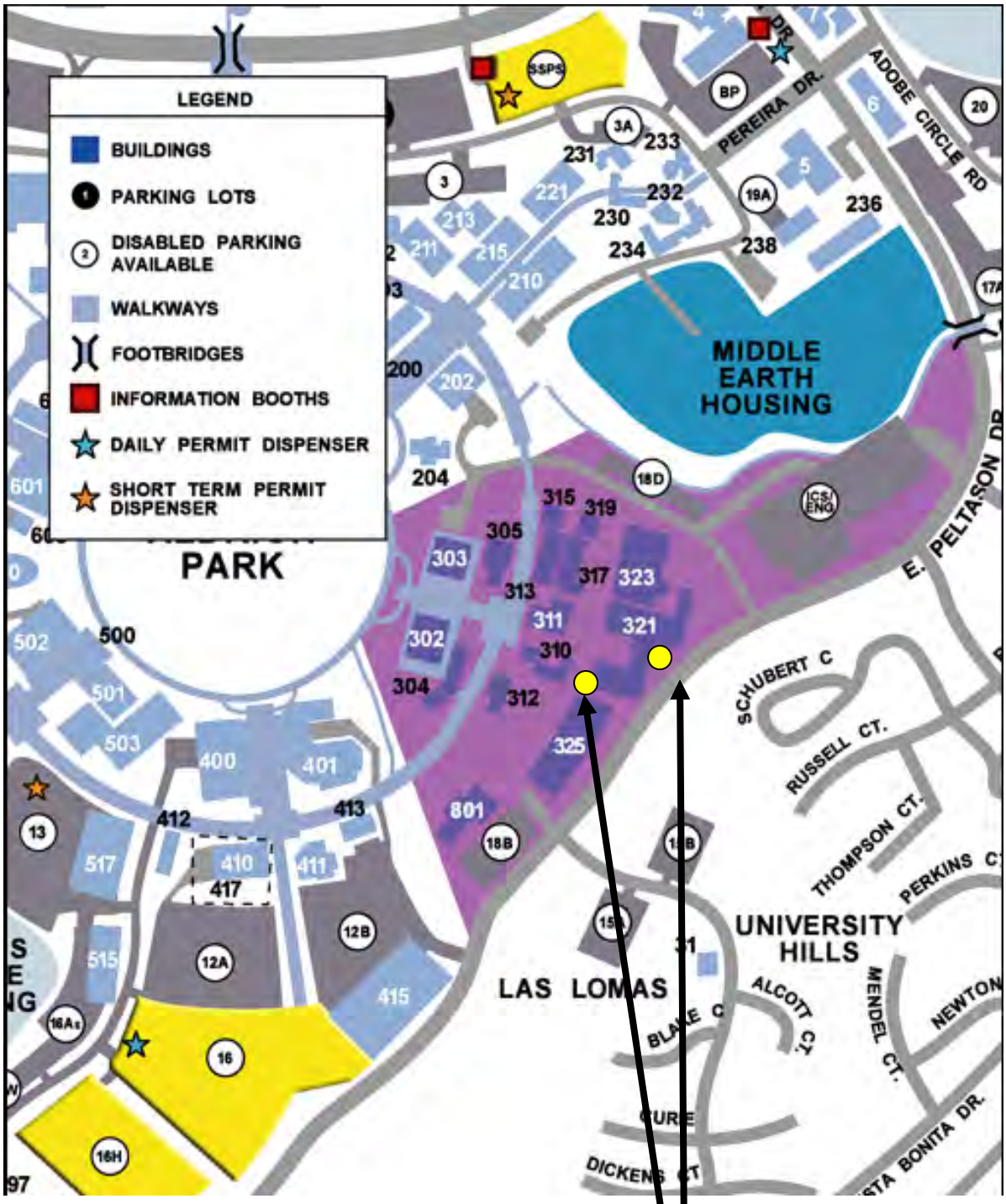
11.4 BiON Laboratory Safety Map

BiON Research Facility

Calit2 – 1st Floor



Fire Alarm	P
Fire Extinguisher	E
Safety Shower	S
Eye Wash	EW
First Aid kits	F
Evacuation Route	→



Building Number 321 is the INRF lab
Building Number 325 is the BiON lab

Yellow Dots area the Building Evacuation Assembly Area

Evacuation Assembly Point

12. Transporting Corrosives in the Lab (Acids and Bases)

Transfer Carts: Chemicals must be transported using transfer carts (or chemical bottle carriers). The transfer carts for acids and bases are made of white polypropylene and kept next to the Chemicals storage room.

Protective Gear: Should be worn whenever handling hazardous chemicals.

- Chemically-resistant gloves
- Face shield (over safety goggles)
- Chemically-resistant apron

Procedures:

1. Bring the transfer cart or chemical bottle carrier next to flammable cabinet remove the chemical you need from the cabinet and place it into the transfer cart or bottle carrier.
    - Use opened containers first.
    - Check the container label to ensure you have the correct chemical.
2. Transfer your chemical to the wet bench storage area.
3. Return the transfer cart or chemical bottle carrier.
4. Pour your chemical according to standard procedures.
    - Bottle lid is on tight.
    - Rinse and dry the outside of the bottle, if any chemical has dripped outside of the bottle is clean and dry.
    - Return the bottle to the proper storage location.

12.1 *Transporting Flammables/Litho Chemicals* (Solvents, Resists & Developers)

Transfer Carts: Chemicals must be transported using transfer carts (or chemical bottle carriers). The transfer carts for solvent, resists and developers are made of metal and kept next to flammables storage cabinets when not in use.

Protective Gear: Should be worn whenever handling hazardous chemicals.

- Chemically-resistant gloves
- Face shield (over safety goggles)
- Chemically-resistant apron

Procedures:

1. Open the Flammables cabinet door slowly (to prevent possible vapors from being pulled out.)
2. Bring and transfer cart next to the open door. Remove the chemical you need from the flammable cabinet and place it into the transfer cart.
    - Use opened containers first.
    - Check the container label to ensure you have the correct chemical.
3. Close the flammable cabinet door.
4. Transfer your chemical to the workstation. Pour your chemical according to standard procedures. Clean and dry the outside of the bottle, if any chemical has been dripped. Return the bottle to the transfer cart.
5. Return the transfer cart to the Flammables storage area.
6. Open the flammable cabinet door slowly.
7. Return the chemical bottle to the storage cabinet. Make sure:
    - Bottle lid is on tight.

- Outside of the bottle is clean and dry.
- Chemical is returned to its proper location.

8. Close the flammables cabinet door.
9. Empty chemical containers should be placed in the designated bins located in the waste disposal room W2312.

12.2 *Local Collection of Liquid Hazardous waste*

Waste that must be collected locally:
All waste that cannot be disposed to the drain must be collected locally. Such waste includes acids, HF, solvents, and liquids containing metals or toxics. For a more detailed description, see section 5.4 of the laboratory Safety Manual or the UCI or INRF websites. If you have any doubts about how to dispose of a chemical, consult with an INRF staff member**.**

*** Where liquid waste collect is done:**

Local collection of chemical waste may be done only at the standard wet bench (see section 5.3 of the Laboratory Safety Manual). You must be trained in the use of a standard wet bench you may use one.

*** How to do liquid waste collection:**

- **Obtain a clean, empty waste container. (**Do not use empty chemical containers, which have not been decontaminated.) Clean, empty containers are stored in waste disposal room W2312. These containers might be previously used for handling chemicals; however, they have been chemically decontaminated. The chemical labels on these containers should be defaced; use a hazardous waste label and fill it out place the label on the container. The clean containers that are supplied are made of polypropylene, which is inert to most, but not all, chemicals used in the lab.

  - If the chemical waste you plan to generate is not compatible to polypropylene (concentrated nitric acid, for example), you should ask INRF/BiON staff for containers that are compatible and if they are available before starting work.

  - If you are working with multiple chemical mixtures, make sure to use separate containers for collecting different types of waste (acid versus base, for example.) Mixing waste may lead to unwanted side-reactions, including heat and explosion.

*** Obtain a Blank hazardous waste disposal labels:**

- Blank labels and clean bottle with vented caps, are available in the waste disposal room W2312. Fill out the hazardous waste disposal label. Attach the label to the waste container (it can be tape to the container)

Pour the used chemical into the labeled waste container:

- This should be done at the wet bench, using a chemically compatible funnel for safe pouring. Rinse the container you used for processing with water three times, pouring the rinse water each time into the waste container. Pour the water used to rinse the substrates into the waste container.

Cap the container:

- Make sure that the outside of the container is clean and dry. Make sure that cap is a vented cap, and the hazardous waste label is securely attached.

Transport the container using the transfer cart:

- Place the container on the appropriate hazardous waste transport cart, using a polypropylene cart for acid and a metal cart for solvent transport to waste to the disposal room W2312.

12.3 Solid Hazardous Waste Disposal

What is solid hazardous waste?

Chemically contaminated objects are considered solid hazardous waste. These include gloves, lab wipes, swabs, plastic syringes and syringe filters. These must not be disposed of in the regular garbage cans because of the out-gas vapors and they may harm the lab staff. Chemically contaminated solid waste should be categorized by chemical class:

- Flammable (solvents, photoresists, etc.)
- Corrosive and other waste (acids and bases, other chemicals)

"Sharps" are objects that can cut or puncture skin. These include silicon or silicon germanium wafers (not GaAs, which must be disposed as chemically hazardous waste), broken glass beakers, razor blades/exacto knives/scalpels, or hypodermic needles. Out of concern for safety, sharps must not be thrown into the regular garbage cans.

How to dispose of solid solvent/resist/flammable waste:

- Work under an exhausted area, to avoid inhaling chemical fumes.
- Place the waste into a plastic bag (Ziploc bags are available throughout the lab).
- Secure the bag, so that it is air-tight
- Place the waste in one of the designated Solid Flammable waste containers.

If you are working with chlorinated solvent waste, follow the procedures for "corrosive and other waste" below. Do not place chlorinated solvent waste into the Solid

How to dispose of corrosive and other chemically contaminated solid waste:

- Work under an exhausted area, to avoid inhaling chemical fumes.
- Place the waste into a hazardous waste bag, available in waste disposal room W2312.
- Secure the end of the bag.
- Double-bag, by placing the waste into a second hazardous waste bag.
- Fill out and attach a hazardous waste tag (available in waste disposal room W2312.)
- Place the waste in the waste disposal room W2312 for pickup.

Sharps:

Sharps should be disposed of in the sharps collection box. This is a large, plastic container is located near the flammables waste containers. When the container is full, notify an INRF/BiON staff member. The container will be put in a box and taped shut; the entire box will be disposed of at once, and replaced with a new box.

Sharps should not contain hazardous chemicals; i.e., beakers should not contain liquid photoresists or corrosives. If you have a sharp object contaminated with chemicals, place the object into a box (an empty wafer box will do), tape it shut, and treat as solid hazardous waste, according to the procedures above.

APPENDIX A

Classes of Hazardous Materials

POISON

OXIDIZER

EXPLOSIVE

FLAMMABLES

CORROSIVE

CARCINOGEN

Proper segregation and storage of hazardous chemicals is challenging in a laboratory environment characterized by the presence of many different chemicals having multiple hazardous properties. Particular attention to proper segregation, storage and handling is warranted for materials labeled with extremely, highly or acutely, such as in “strong oxidizer”, “extremely flammable” or “highly toxic.”

Table of Contents

(For additional information regarding chemical hazards, consult the on-line NIOSH Pocket Guide to Chemical Hazards at: **www.cdc.gov/niosh/npg/pgintrod.html)**.

I. ACIDS

Characteristics	• Typically all acids are soluble in water and release heat • Specific properties of individual acids must be ascertained prior to commencing clean-up procedures	
Storage Precautions	• Store large bottles of acids on low shelf or in acid cabinets • Segregate oxidizing acids from organic acids, flammable and combustible materials • Segregate acids from bases and active metals such as sodium, potassium, magnesium, etc. • Segregate acids from chemicals which could generate toxic or flammable gases upon contact such as sodium metal, cyanide, and iron sulfide • Use bottle carriers for transporting acid bottles • Have spill control pillows or acid neutralizers available in case of acid spills • Store in cool, dry, well-ventilated location	
Potential Hazards	Fire	• Inorganic acids are not usually flammable, organic acids are flammable
	Explosion	• Container may explode due to heat or fire
	Health	• Vapors irritating • Corrosive to skin, eyes, and lungs • Contact can result in severe burns • Some are toxic beyond irritation or corrosiveness
Detection of Release	• Turns Litmus paper red, pH range 5 to 1 • Eye, nose, throat, skin irritation • Air monitoring	
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Stop leak if without risk to personnel • Do not touch spilled liquid • If on fire extinguish using suitable extinguishing agent • Neutralize with (bi)-carbonates when feasible	
Personal Protection	• Avoid breathing vapors • Avoid bodily contact • Keep upwind • Wear neoprene gloves, boots, and goggles • Full protective clothing may be necessary if significant contact with material	
First Aid	• Move victim to fresh air • Remove contaminated clothing • In case of contact, flush skin or eyes with water • Keep victim quiet and warm • Keep victim under observation for delayed effects • Seek medical attention for hydrogen fluoride burns	

Common Acids:

Acetic Acid†	Hydrofluoric Acid	Phosphoric Acid
Benzoic Acid†	Hydroiodic Acid	Phosphorous Acid

Chloroacetic Acid†	Iodic Acid‡	Propionic Acid†
Chromic Acid‡	Muriatic Acid	Sulfamic Acid†
Hydrobromic Acid‡	Nitric Acid‡	Sulfanilic Acid†
Hydrobromous Acid	Nitrous Acid	Sulfuric Acid‡
Hydrochloric Acid	Perchloric Acid‡	Sulfurous Acid
Hydrochlorous Acid	Phenol†	

†*Indicates organic acids.*
‡*Indicates strong oxidizing acids.*

II. HYDROFLUORIC ACID

Characteristics	• Extremely hazardous • Highly corrosive acid that attacks silicates such as glass. • Pure hydrofluoric acid ***dissolves*** glass, leaving a brilliant, acid-polished surface	
Storage Precautions	• Store in a cool, dry, well-ventilated place away from incompatible materials • Avoid contact with glass, concrete, metals, water, acids, oxidizers, reducers, alkalis, combustibles, organics, and ceramics • Secondary containment trays, constructed of polyethylene are recommended • **Never store in glass containers**	
	Health	• Skin contact with hydrofluoric acid may cause severe burns. • **Burns may not manifest immediately at concentrations of less than 50%.** • Fluoride ions penetrate the skin easily and can cause considerable damage • Eye contact can result in destruction or opacification of the cornea • Blindness may result from severe or untreated exposure, immediate first aid is necessary • Concentrated solution and anhydrous hydrofluoric acid produce pungent fumes on contact with air. These fumes can cause nasal congestion and bronchitis, even in low concentrations. • Burns that occur when the vapors or liquid contact the oral mucosa or upper airway may cause severe swelling, to the point of airway obstruction • Mode of action is to bind calcium whenever contact occurs with skin or other body tissues • **Tissue destruction and neutralization may proceed for days** • Because calcium is necessary for cell life, its binding can bring about rapid cell death • If exposure is extensive, excessive amounts of calcium may be inactivated and adequate supplies of calcium may be unavailable for vital bodily functions
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	

Personal Protection	• Be sure that you are using protective equipment that has been shown to effectively protect against hydrofluoric acid exposure • Always handle in a properly functioning fume hood and insure that the area is equipped with a safety shower and eyewash • Wear goggles, face shield, neoprene gloves, and acid resistant apron • Familiarize yourself with the MSDS before handling.
First Aid	• Move victim to a safe location, and seek medical attention • Use protective equipment when handling a contaminated victim • **Skin:** Immediately flush the exposed skin for 5 minutes with water and apply calcium gluconate gel. Use two pairs of nitrile gloves while applying gel. Reapply calcium gluconate gel every 10 minutes until emergency help arrives. • **Eyes:** Immediately flush eyes with water for 15 minutes**. Dial 911** • **Inhalation: Dial 911** • **All hydrofluoric acid burns are to be evaluated by a physician** * Obtain calcium gluconate gel from Physical Sciences Storehouse.

III. **BASES**

Characteristics	• Typically soluble in water and release heat • Specific properties of individual bases must be ascertained prior to commencing clean-up procedures	
Storage Precautions	• Segregate bases from acids • Store solutions of inorganic hydroxides in polyethylene containers • Have spill control pillows or caustic neutralizers available for caustic spills • Store in cool, dry, well-ventilated location	
Potential Hazards	Fire	• Typically soluble in water
	Explosion	• Container may explode due to heat or fire
	Health	• Damage to eyes, skin from corrosive action • Fine dust can cause damage to eyes, upper respiratory tract and lungs • Skin irritant
Detection of Release	• Turns Litmus paper blue, pH range 8 to 14 • Slippery feeling in solution • Eye, nose, throat, skin irritation • Air monitoring	
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Stop leak if without risk to personnel • Do not touch spilled liquid • Neutralize with dilute acid, e.g. citric acid, by trained response personnel • Capture spilled material for later disposal	
Personal Protection	• Avoid breathing vapors • Avoid bodily contact • Keep upwind • Wear appropriate chemical protective gloves, boots, and goggles • Full protective clothing may be necessary if significant contact with material is anticipated	
First Aid	• Move victim to fresh air • Remove and isolate contaminated clothing • In case of contact, flush skin or eyes with water	

Common Bases:

Ammonium Hydroxide	Carbonates, Salts of[2]	Potassium Hydroxide
Bicarbonates, Salts of[1]	Calcium Hydroxide	Sodium Hydroxide

[1]*Potassium bicarbonate, sodium bicarbonate, etc.*
[2]*Calcium carbonate, sodium carbonate.*

IV. **SOLVENTS**

Characteristics	• May be flammable, toxic, or carcinogenic • Fire and explosion hazard • Most are easily absorbed through skin	
Storage Precautions	• Store in approved safety cans or cabinets • Do not use plastics for storage of large amounts of flammable liquids • Segregate from oxidizers • Keep away from any source of ignition: flames, localized heat or sparks • Safety cans or drums containing flammable liquids should be grounded and bonded when being used • Keep fire fighting equipment readily available • Have spill cleanup materials handy • Do not exceed the recommended maximum container size for flammable and combustible liquids (Call EH&S for more information) • Store in cool, dry, well-ventilated location	
Potential Hazards	Fire	• Maybe flammable • May be ignited by heat • Vapors may travel to ignition source
	Explosion	• Container may explode due to heat or fire • Vapor explosion hazard indoors, outside, and in confined spaces
	Health	• Some are toxic • Can replace oxygen and cause suffocation • Irritation of eyes, nose, throat, lungs • May cause headaches, dizziness, and sleepiness • Higher levels of exposure may cause unconsciousness, brain and central nervous system effects • Skin contact may cause dryness, irritation and dermatitis • Chronic effects: liver, kidney, central nervous system, and brain damage
Detection of Release	• **Odor thresholds vary widely from person to person, don't depend on odor for warning** • Some solvents produce "olfactory fatigue" - rapid loss of ability to smell the odor • Solvent vapors are invisible • Detected by industrial hygiene instruments	
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Stop leak if without risk to personnel	
Personal Protection	• Avoid breathing vapors • Wear appropriate protective clothing • Wear self-contained breathing apparatus	

First Aid	• Move victim to fresh air • Remove contaminated clothing • In case of contact, flush skin or eyes with water • Keep victim quiet and warm • If not breathing give artificial respiration

Common Solvents:

Acetaldehyde	Ethylamine*	Methyl Ethyl Ketone
Acetone	Ethyl Benzene	Methyl Formate
Acetyl Chloride	Ethylene Dichloride	Methyl Isobutyl Ketone
Allyl Alcohol*	Ethyl Ether	Methyl Methacrylate
Allyl Chloride	Ethyl Formate	Methyl Propryl Ketone
N-Amyl Acetate	Furan	Morpholine*
N-Amyl Alcohol	Gasoline	Napthalene*
Benzene*	Heptane	Nitromethane†
N-Butyl Acetate	Hexane*	Octane
N-Butyl Alcohol*	Hydrazine*	Piperidine
N-Butylamine*	Isobutyl Alcohol	Propanol*
Carbon Disulfide*	Isopropyl Acetate	Propylene Oxide
Chlorobenzene	Isopropyl Alcohol	Pyridine
Cyclohexane	Isopropyl Ether	Styrene
Diethylamine*	Mesityl Oxide	Tetrahydrofuran
Diethyl Carbonate	Methanol*	Toluene*
p-Dioxane*	Methyl Acetate	Turpentine
Ethanol	Methyl Acrylate*	Vinyl Acetate
Ethyl Acetate	Methylal	Xylene
Ethyl Acrylate	Methyl Butyl Ketone*	

* Readily absorbed through the skin.
†Most nitrohydrocarbons are flammable.

V. **OXIDIZERS**

Characteristics	Contains available oxygen that can make ignition easier or cause a fire to burn with intensity.	
Storage Precautions	• Store in a cool, dry place, well-ventilated location in original containers. • Keep away from flammable and combustible materials (such as paper, wood, etc.) • Keep away from reducing agents such as zinc, alkaline metals, and formic acid.	
Potential Hazards	Fire/Explosion	• Chlorites, chlorates, and perchlorates are potentially explosive in contact with combustibles, sulfur organic materials, metal powders. • Can explode if subjected to shock, friction, or heat.

	Health	• May be irritating to eyes, nose, throat, or case burns. • Poisonous if ingested.
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
Personal Protection	• Use inside a fume hood. • Use appropriate chemical resistant gloves. • Use eye protection	
First Aid	• In case of contact, flush skin or eyes with water for 15 minutes. • Remove and isolate contaminated clothing. • Move victim to fresh air. • If not breathing, give artificial respiration, if trained.	

Common Oxidizers:

Chlorites	Chlorates
Perchlorates	Nitrites
Nitrates	

Oxidation Reactions

These reactions tend to generate heat and are often explosive. The following examples of typical oxidizers may:

Increase Rate of Combustion

Aluminum Nitrate	Perchloric Acid 60% or less
Ammonium Persulfate	Potassium Chloriate
Barium Chlorate	Potassium Dichromate
Barium Peroxide	Potassium Nitrate
Calcium Chlorate	Potassium Persulfate
Calcium Nitrate	Silver Nitrate
Calcium Peroxide	Silver Nitrite
Cupric Nitrate	Sodium Perborate
Hydrogen Peroxide	Sodium Perchlorate
Lead Nitrate	Sodium Persulfate
Lithium Hypochlorite	Strontium chlorate
Lithium Peroxide	Strontium nitrate
Magnesium Nitrate	Strontium nitrite
Magnesium Perchlorate	Thorium nitrite
Magnesium Peroxide	Uranium nitrate
Nickel Nitrate	Zinc chlorate
Nitric Acid 70% or less	Zinc peroxide

Cause Spontaneous Ignition

Calcium Hypochlorite	Sodium Chlorite (40%)
Chromic Acid	Sodium Peroxide
Hydrogen Peroxide (27.5-52%)	Sodium Permanganate

Nitric Acid
Potassium Bromate
Potassium Permanganate
Trichloroisocyanuric Acid
Sodium Dichloroisocyanurate

Decompose with Catalyst or Heat

Ammonium Dichromate
Hydrogen Peroxide (52-91%)
Calcium Hypochlorite (>50%)
Perchloric Acid (60-72.5%)
Potassium Dichloroisocyanurate
Sodium Dichloroisocyanurate

Cause Explosive Reaction when exposed to Catalyst, Heat, Shock, or Friction

Ammonium Perchlorate
Ammonium Permanganate
Perchloric Acid
Potassium Superoxide

VI. TOXIC COMPOUNDS

Characteristics	• Can be a solid, liquid or gas • Warning: These chemicals are dangerous or extremely dangerous to health and life when inhaled, swallowed, or absorbed by skin contact. Take proper precautionary measures to avoid exposure	
Storage Precautions	• Store according to hazardous nature of chemical, using appropriate security when necessary • Store in cool, dry, well-ventilated location	
Potential Hazards	Fire	• May be ignited by sparks or flames
	Explosion	• Container may explode due to heat or fire
	Health	• Poisonous by inhalation, ingestion, or skin contact • May cause burns to skin or eyes
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
Personal Protection	• Avoid breathing vapors • Avoid bodily contact • Wear appropriate chemical protective clothing • Handle only inside a fume hood	
First Aid	• Move victim to fresh air • Remove and isolate contaminated clothing • In case of contact, flush skin or eyes with water for at least 15 minutes • Keep victim quiet and warm • If not breathing give artificial respiration • Keep victim under observation for delayed effects	

Common Toxics:

Solids

Antimony Compounds
Arsenic Compounds
Barium Compounds
Beryllium Compounds
Cadmium Compounds
Calcium Oxide
Chromates, Salts of
Cyanide, Salts of
Fluorides, Salts of
Iodine
Lead Compounds
Mercuric Compounds
Oxalic Acid
Phenol
Phosphorous, Yellow
Phosphorous Pentachloride
Phosphorous Pentasulfide
Picric Acid
Potassium
Selenium Compounds
Silver Nitrate
Sodium Hydroxide
Sodium Hypochlorite

Liquids

Aniline
Bromine
Carbon Disulfide
Carbon Tetrachloride
Chloroform
Chromic Acid
p-Dioxane
Formic Acid
Hydrazine
Hydrobromic Acid
Hydrochloric Acid
Hydrofluoric Acid
Hydrogen Peroxide
Mercury
Perchloric Acid
Phosphorous Trichloride
Sulfuric Acid
Tetrachloroethylene

Gases

Carbon Monoxide
Chlorine
Cyanogen
Diborane
Fluorine
Formaldehyde
Hydrogen Bromide
Hydrogen Chloride
Hydrogen Cyanide
Hydrogen Sulfide
Nitrogen Dioxide
Ozone
Sulfur Dioxide

VII. **WATER REACTIVE CHEMICALS**

Characteristics	• Warning: These chemicals react with water to yield flammable or toxic gases or other hazardous conditions.	
Storage Precautions	• Store in a cool, dry, well-ventilated location • Avoid water or moisture • Store at least 24" off of floor	
Potential Hazards	Fire	• May react vigorously in presence of water causing fire or explosion • Many are flammable
	Explosion	• May explode violently
	Health	• May produce toxic gas • May cause severe burns
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury • Evaluate the area	
	• Keep material dry • Do not use water, carbon dioxide, or halon on material; use dry chemical ABC or D-type extinguisher	
Personal Protection	• Avoid breathing vapors • Wear appropriate personal protection • Keep upwind	
First Aid	• Move victim to fresh air • Remove contaminated clothing • Wipe material from skin immediately • In case of contact, flush skin or eyes with water for at least 15 minutes	

Common Water Reactive Chemicals:

Solids
Aluminum Chloride, Anhydrous
Calcium Carbide
Lithium
Magnesium
Phosphorous Pentachloride
Phosphorous Pentasulfide
Potassium
Sodium
Organometallic compounds

Liquids
Acetyl Chloride
Phosphorous Trichloride
Silicon Tetrachloride
Stannic Chloride
Sulfur Chloride
Thionyl Chloride
Aluminum Borohydride
and all other hydrides

VIII. **PYROPHORIC SUBSTANCES**

Characteristics	• Warning: Pyrophoric substances ignite spontaneously upon contact with air. • All are flammable • **Notify EH&S of use of pyrophoric prior to purchase to ensure proper safety equipment is available.**	
Storage Precautions	• Use only in gas cabinet**. Obtain approval from Fire Marshall prior to use.** • **Flow Restricting Orifice must be used when using silane.** • Store in cool, dry, well-ventilated location • Materials must be stored under a blanket of inert gas.	
Potential Hazards	Fire	• Ignites spontaneously on contact with air • May react violently with water oxidizing agents, halogenated hydrocarbons and alcohols
	Explosion	• May be explosive when mixed with oxidizing materials
	Health	• Can cause severe burns • Inhalation of some alkyl metal fumes can cause metal fume fever
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing injury	
	• For fire, use dry sand or vermiculite • For phosphorous use water • Refer to MSDS – response must be material specific	
Personal Protection	• Isolate area, and deny entry • Avoid breathing fumes • Keep upwind • Keep unprotected personnel away • Wear appropriate personal protection	
First Aid	• Move victim to fresh air • Remove and isolate contaminated clothing • Remove material from skin immediately • In case of contact, flush skin or eyes with water for at least 15 minutes	

Common Pyrophoric Substances:

Boron	Diborane	Methyllithium
Butyllithium	Dichloroborane	Nickel†
Cadmium†	2-Furaldehyde	Phorphorous, Yellow‡
Calcium†	Iron†	Titanium†
Chromium†	Lead†	Selectride
Cobalt†	Manganese†	Silane

†Finely divided metals form a pyrophoric hazard.
‡Phosphorous, Yellow should be stored and cut under water.

IX. CRYOGENIC FLUIDS

Characteristics	• Extremely low temperature (< -100°F) • Very large range of expansion from liquid to gas phase	
Storage Precautions	• Store only in Dewar flasks • Store in well-ventilated location	
Potential Hazards	Fire	• Many are flammable • Some may condense oxygen from the air
	Explosion	• Container may rupture if exposed to fire or relief valve fails
	Health	• Although many are non-toxic, vapors in confined spaces can cause dizziness or asphyxiation • Contact can cause severe frostbite, burns. Eyes vulnerable to exposure
Detection of Release	• Cold boil off-gases condenses creating fog. • Most cryogenic liquids are colorless, odorless, tasteless except LOX which is blue.	
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Extinguish fire using a suitable agent • Cool affected container, so not use water on material itself • Stop leak if you can do so without risk	
Personal Protection	• Keep unprotected personnel away • **Wear appropriate cryogenic protective clothing, eye protection and face shield** • **Use only in well ventilated places.** • Cryogenics displaces oxygen.	
First Aid	• Move victim to fresh air • If not breathing give artificial respiration • For frostbite, thaw frosted parts with water • Keep victim quiet • Maintain normal body temperature	

Common Cryogenic Fluids:

Oxygen (LOX)	Nitrogen (LN_2)
Argon	Hydrogen
Helium	Neon
Xenon	Liquefied natural gas (LNG)

Expansion Ratio* (gas: liquid):

Cryogenic	**Expansion Ratio**
Liquid argon	840 to 1
Liquid fluorine	980 to1

Cryogenic	**Expansion Ratio**
Liquid natural gas	635 to 1
Liquid neon	1,445 to 1

Liquid helium	700 to 1
Liquid hydrogen	848 to 1
Liquid krypton	695 to 1

Liquid nitrogen	694 to 1
Liquid oxygen	857 to 1
Liquid xenon	560 to 1

* Source: The Common Sense Approach to Hazardous Materials, F.L. Fire, Fire Engineering, New York, New York, 1986.

X. ASPHYXIANT GASES

Characteristics	• Mostly inert, non-reactive gases; some flammable or toxic gases can also be simple asphyxiants • **Consult with gas suppliers to ensure proper piping and manifold compatibility** • **Do not use in confined spaces with poor ventilation.**	
Potential Hazards	Fire	• Some asphyxiants are flammable, may release toxic gases
	Explosion	• Gas cylinders may rupture in a fire
	Health	• Possible asphyxiation, may cause frostbite. Some may react with air forming toxic compounds
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Check for oxygen depletion • Extinguish fire using suitable agent • Stop leak if you can do it without risk, and have been trained	
Personal Protection	• Safety glasses and face shield • Rubber gloves • Closed toed shoes	
First Aid	• Move victim to fresh air • If not breathing, give artificial respiration • If breathing is difficult, give oxygen	

Common Asphyxiant Gases:

Nitrogen	Helium
Argon	Other inert gases

XI. **FLAMMABLE GASES**

<table>
<tr><td>Characteristics</td><td colspan="2">• Compressed gases in cylinders
• Gases may be mixtures in cylinders
• May be toxic and/or caustic
• Use flame arresters to prevent flashbacks.
• Delivery pressure for acetylene gas should not exceed 15 psi gauge pressure.</td></tr>
<tr><td>Storage Precautions</td><td colspan="2">• Store in upright position and in cool, dry, well ventilated areas
• Keep away from flammable liquids and from highly combustible materials and similar substances.
• Keep away from arcing electrical equipment, open flames or other sources of ignition.
• Consult with gas suppliers to ensure proper piping and manifold compatibility</td></tr>
<tr><td rowspan="3">Potential Hazards</td><td>Fire</td><td>• Extremely flammable
• May be ignited by heat
• Vapors may travel to ignition source</td></tr>
<tr><td>Explosion</td><td>• Containers may explode in heat of fire
• Vapor explosion hazard indoors, outside, and confined spaces
• Acetylene forms explosive compounds with copper, silver, and mercury.</td></tr>
<tr><td>Health</td><td>• Some are toxic
• All can replace oxygen and cause suffocation</td></tr>
<tr><td rowspan="2">Immediate Action</td><td colspan="2">NOTIFY EH&S OF ANY RELEASE:
• Beyond immediate work area
• Causing personal injury</td></tr>
<tr><td colspan="2">• Stop leak if you can do it without risk, and have been trained</td></tr>
<tr><td>Personal Protection</td><td colspan="2">• Avoid breathing fumes
• Wear appropriate protective clothing
• Wear self contained breathing apparatus</td></tr>
<tr><td>First Aid</td><td colspan="2">• Move victim to fresh air
• If not breathing, give artificial respiration
• For frostbite, thaw frosted parts with water
• Keep victim quiet and warm</td></tr>
</table>

Common Flammable Gases:

Acetylene	Hydrogen
Propane	Oxygen

XII. **TOXIC GASES**

Characteristics	• Gases may be chemical asphyxiants, corrosives, and/or poisonous (other than a chemical asphyxiant)	
Storage Precautions	• **Must be used inside a gas cabinet and toxic gas monitors installed.** • **Corrosive gases should be stored for the shortest possible period before use, preferably < 3 months** • **Consult with gas suppliers to ensure proper piping and manifold compatibility** • **Notify Fire Marshal or Chemical Hygiene Officer prior to using highly toxic gases**	
Potential Hazards	Fire	• Many toxic gases are highly flammable • Vapors may travel to ignition source and flash back • Cylinders may rupture and rocket
	Explosion	• Containers may explode in heat of fire • Vapor explosion hazard indoors, outside, or in sewers
	Health	• Poisonous if inhaled or absorbed • Contact may cause burns to skin or eyes • Contact with liquid may cause frostbite • Respiratory irritant
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Do not extinguish fire unless flow can be stopped • Consult with MSDS for techniques for specific gases • Keep material out of water sources	
Personal Protection	• Avoid breathing vapors • Avoid bodily contact with material • Wear appropriate chemical protective clothing	
First Aid	• Move victim to fresh air • If not breathing, give artificial respiration • In case of contact with material, flush with running water for at least 15 minutes • Remove contaminated clothing • Call physician immediately	

Common Toxic Gases:

Phosgene	Hydrogen Cyanide
Hydrogen Sulfide	Carbon Monoxide
Chlorine	Fluorine

Facts About Selected Toxic Gases

GAS	ARSINE	PHOSPHINE	GERMANE	HYDROGEN SELENIDE	SILANE
MAJOR HAZARDS	Extremely toxic Flammable	Extremely toxic Flammable	Extremely toxic Flammable	Extremely toxic Flammable	Pyrophoric
COLOR	None	None	None	None	None, White smoky fire
ODOR	Garlic-like	Dead fish	Pungent, Nauseating	Rotten egg, Pungent, Irritating	None
TLV, **ppm**	0.05	0.3	0.2	0.05	0.5
ODOR THRESHOLD RANGE, ppm	0.1	0.02-2.6	------	0.0004-3.3	------
DANGER LEVEL	~10 ppm	~100 ppm			~1000 ppm
TARGET ORGANS	Blood cells Kidneys	Cellular Oxidase System	Blood cells Kidneys	Lungs, Eyes, Liver	Fire is main Hazard
PHYSIOLOGICAL EFFECTS					
ACUTE	Abdominal pain, Nausea, Vomiting	Vertigo, Weakness, Cramps, Tremors	Hemolysis, Kidney failure, Anemia	Respiratory distress, Nausea	Thermal burns
DELAYED 2-24 Hrs.	Respiratory distress, Anemia	Respiratory distress, CNS difficulty, Pulmonary edema		Eye inflammation	Headaches & Nausea
4-6 Hrs.	Bloody urine		Bloody urine		
12-48 Hrs.	Jaundice		Jaundice		Coma
>12 Hrs.	Kidney failure, Liver, Heart damage	Lung, Kidney failure	Kidney failure, Central nervous system (CNS) collapse	Pulmonary edema	
FIRE EXPLOSION HAZARD	Similar to hydrogen	Autoignition temp 212°f	Explodes above 330°c		Pyrophoric gas
LEL/UEL	4%/74% for Hydrogen	4%/74% for hydrogen			0%/100%
COMMENT		May explode in contact with halogen or oxygen. Do not use halogen fire extinguishers			Can cause severe explosion under some undefined conditions
REACTIVITY WITH WATER	Dissolves readily	Soluble	Soluble	No data, probably somewhat soluble	Rapidly hydrolyzed to SiO_2

XIII. **REACTIVE OR EXPLOSIVE CHEMICALS**

Characteristics	• Warning: These chemicals are sensitive to heat and shock • Peroxide forming chemicals, under proper conditions will form explosive peroxides which can be detonated by shock or heat.	
Storage Precautions	• Avoid exposure to heat and mechanical shock • Label storage unit "Potential Explosion Hazard" • Label containers with receiving, opening, and disposal dates. • Dispose of peroxide forming chemicals before expected date of first peroxide formation in accordance with lab policy (6 months after opening or by manufacturers expiration date.) • Test for the presence of peroxides periodically. • Store in cool, dry, well-ventilated location	
Potential Hazards	Fire	• Many ignite a chain reaction with other chemicals that could become violent
	Explosion	• Containers may detonate by mechanical shock, elevated temperatures and chemical reactions. • Catalytic effect of metallic contamination can lead to explosive situations
	Health	• May cause severe burns and injuries
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury • Do not extinguish fire until chemical reaction has ceased • Evacuate all personnel from the area.	
Personal Protection	• Safety glass with side shields or goggles should be worn • When possible, use the reactive chemical in a fume hood • Use of heavy, transparent plastic explosion shield on all sides should be in place to provide extra protection in addition to the hood window. • If feasible, wear heavy leather gloves when handling reactive compounds. • Wear appropriate clothing (i.e., flame resistant lab coat)	
First Aid	• Seek medical attention immediately	

Common Reactive and Explosive Chemicals:

Acetylides	Diazo compounds	Perchlorates
Azides	Nitrates	Peroxides
Bromates	Nitrates, Organic	Picrates
Chlorates	Nitro compounds	
Chlorites	Nitroso compounds	

Classes of Chemicals that Can Form Peroxides Upon Aging:

1. Class I

Unsaturated materials, especially those of low molecular weight, may polymerize violently and hazardously due to peroxide initiation.

Acrylic Acid	Methyl ethacrylate	Vinyl chloride
Acrylonitrile	Styrene	Vinyl chloride
Butadiene	Tetrafluoroethylene	Vinyl pyridine
Chlorobutadiene (Chloroprene)	Vinyl acetate	Vinylidene Chloride
Chlorotrifluoroethylene	Vinyl acetylene	

2. Class II

The following chemicals are a peroxide hazard upon concentration (distillation/evaporation). A test for peroxide should be performed if concentration is intended or suspected.

Acetal	Dicyclopentadiene	Furan
Cumene	Diethylene Glycol Dimethyl Ether (Diglyme)	Methyl Acetylene
Cyclohexene		Methyl Cyclopentane
Cyclooctene	Diethyl Ether	Methyl-*i*-butyl Ketone
Cyclopentene	Dioxane (*p*-Dioxane)	Tetrahydrofuran
Diacetylene	Ethylene Glycol Dimethyl Ether	Tetrahydronathalene
		Vinyl Ethers

3. Class III

Peroxides derived from the following compounds may explode without concentration.

Organic	Inorganic
Divinyl Ether	Potassium Metal
Divinyl Acetylene	Potassium Amide
Isopropyl Ether	Sodium Amide
Vinyliene Chloride	

XIV. **CARCINOGENS**

Characteristics	• A substance or agent that causes cancer
Storage Precautions	• A hazard warning sign incorporating the carcinogen symbol must be posted at all areas where carcinogens are used or stored • Segregate carcinogens • Consult with EH&S prior to handling • Store in cool, dry, well-ventilated location
Potential Hazards	Consult MSDS for each chemical.
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury
Personal Protection	• The Standard Operating Procedures (SOP) outlines safety procedures that should be followed when working with carcinogens • Users of any regulated carcinogens are required to fill out a SOP and **Supplemental Information Form for Chemicals Requiring Cal/OSHA Registration** and submit the form to EH&S for review and approval. • Use only inside fume hoods and regulated areas.
First Aid	Notify EH&S of any exposures.

Cal-OSHA Reportable Hazardous Chemicals:

Scope: Applies to occupational settings where these chemicals are manufactured, processed, used, repackaged, released, stored or otherwise handled.

Table 1: Must complete Supplemental Information Form for Chemical Requiring Registration with Cal-OSHA:

Name	**If above % weight or volume**
2-Acetylaminofluorene	1.0
4-Aminodiphenyl	0.1
Benzidine (and its salts)	0.1
3,3'-Dichlorobenzidine (and its salts)	1.0
4-Dimethylaminoazobenzene	1.0
alpha-Naphthylamine	1.0
beta-naphthylamine	0.1
4-Nitrosodimethylamine	1.0
N-Nitrosodimethylamine	1.0
beta-Propiolactone	1.0
bis-Chloromethyl ether	0.1
Methyl chloromethyl ether	0.1
Ethyleneimine	1.0

Table 2: May have to complete Supplemental Information Form for Chemical Requiring Registration with Cal-OSHA. Contact the Chemical Hygiene Officer at 824-5730 for assistance.

Name	**If exposure occurring above:**
Acrylonitrile	PEL[1] (2ppm)
Asbestos	PEL (0.1ff/cc[2]) or 30 minute-excursion (1ff/cc)
Benzene	STEL[3] (5ppm) or PEL (1ppm)
Cadmium	PEL (5ug/m3)
Beryllium	any potential exposure
Ethylene Dibromide	any exposure level where composition ≥ 0.1%[4]
Ethylene Oxide	STEL (5ppm) or PEL (1ppm)
Formaldehyde	STEL (2ppm) or PEL (0.75ppm)
Inorganice Arsenic	PEL (0.01mg/m3)
Methylene Chloride	STEL (125ppm) or PEL (25ppm)
Methylenedianaline	any potential exposure
Vinyl Chloride	STEL (5ppm) or PEL (1ppm)
1,3 Butadiene	any exposure level where composition ≥ 0.1%

The list above only represents "regulated" carcinogens. There are however many other suspect carcinogens. For a complete list of all categories of carcinogens, go to the following Internet sites:

- International Agency for Research of Cancer (IARC): http://monographs.iarc.fr/ENG/Classification/index.php.
- National Toxicology Program (NTP): http://ehp.niehs.nih.gov/roc/toc10.html
- National Institute of Occupational Health (NIOSH): http://www.cdc.gov/niosh/npotocca.html
- **FAQs** about developing Standard Operating Procedures for carcinogens.

[1] PEL Cal-OSHA permissible exposure limit 8-hour time weighted average.
[2] ff/cc Friable fibers per cubic centimeter of air
[3] STEL Cal-OSHA short-term exposure limit 15 minute.
[4] % by weight or volume.

XV. CDC SELECT AGENTS, USDA HIGH CONSEQUENCE LIVESTOCK PATHOGENS OR PLANT PATHOGENS

Definition	UCI policy states that all Select Agent users register with EH&S **BEFORE** any agent can be ordered. Contact the Biosafety Officer at (949) 824-9888 or Biosafety Officer at (949) 824-9888 for more information. • The Select Agents regulations (42 CFR Part 72.6, Additional Requirements for Facilities Transferring or Receiving Select Agents) which became effective on April 15, 1997, was designed to minimize the potential inappropriate use of certain biological agents and toxins whose release could have an adverse public health impact or be used for bioterrorism.
Primary Objectives	• Establish system of safeguards to be followed when specific agents are transferred, used or possessed. • Collect and provide information concerning the location where certain potentially hazardous agents are transferred. • Track the acquisition and transfer of these specific agents. • Establish a process for alerting appropriate authorities if an unauthorized attempt is made to acquire these agents.
List of Restricted "Select Agents" by Category	**USDA High Consequence Livestock Pathogens and Toxins**
	African Horse Sickness Virus African Swine Fever Virus Akabane Virus Avian Influenza Virus (Highly Pathogenic) Blue Tongue Virus (Exotic) Bovine Spongiform Encephalopathy Agent Camel Pox Virus Classical Swine Fever Virus Cowdria Ruminantium (Heartwater) Foot And Mouth Disease Virus Goat Pox Virus Japanese Encephalitis Virus Lumpy Skin Disease Virus Malignant Catarrhal Fever Virus Menangle Virus Mycoplasma Capricolum/M.F 38/M.Mycoides Capri (Contagious Caprinepleuropneumonia Agent) Mycoplasma Mycoides (Contagious Bovine Pleuropneumonia Agent) Newcastle Disease Virus (Exotic) Peste Des Petits Ruminants Virus Rinderpest Virus Sheep Pox Virus Swine Vesicular Disease Virus Vesicular Stomatitis Virus (Exotic)

List of Restricted "Select Agents" by Category (Cont.)	**DHHS-CDC Select Agents**	
		Cercopithecine Herpes Virus (Simian Herpes B Virus) Coccidioides posadasii Crimean-Congo Haemorrhagic Fever Virus Ebola Viruses Lassa Fever Virus Marburg Virus Rickettsia prowazekii Rickettsia rickettsii South American Haemorrhagic Fever Viruses (Junin, Machupo, Sabia, Flexal, Guanarito) Tick-Borne Encephalitis Complex (flavi) Viruses (Central European Tick-borne encephalitis, Far Eastern Tick-borne encephalitis, Russian Spring and Summer encephalitis, Kyasanur Forest disease, Omsk Hemorrhagic Fever) Variola Major Virus (Smallpox Virus) and Variola Minor Virus (Alastrim) Viruses Causing Hantavirus Pulmonary Syndrome Yellow Fever Virus Yersinia pestis Abrin Conotoxins Diacetoxyscirpenol Ricin Saxitoxin Tetrodotoxin
	USDA-DHHS CDC Overlap Agents	

		Bacillus anthracis Brucella abortus Brucella melitensis Brucella suis Burkholderia (Pseudomonas) Mallei Burkholderia (Pseudomonas) Pseudomallei Clostridium Botulinum Coccidioides Immitis Coxiella Burnetii Eastern Equine Encephalitis Virus Equine Morbillivirus (Hendra Virus) Francisella tularensis Nipah Virus Rift Valley Fever Virus Venezuelan Equine Encephalitis Virus Botulinum Neurotoxin producing species of Clostridium Botulinum Neurotoxins Clostridium Perfringens Epsilon Toxin Shigatoxin and Shiga-like ribosome inactivating proteins Staphylococcal Enterotoxins T-2 Toxin
	USDA-APHIS Plant Pathogens	
		Plum pox potyvirus Liberobacter africianus, Liberobacter asiaticus Xanthomonas oryzae pv. Oryzicola Xylella fastidiosa (citrus variegated chlorosis strain) Peronoscleospora philippinensis Phakopsora pachyrhizi Sclerophthora rayssiae var zeae Synchytriun endobioticum
	Poliovirus or Materials Potentially Containing Poliovirus	

Please notify UCI Biosafety Officer if your laboratory has any of the listed Select Agents at 824-9888.

XVI. **ANESTHETIC GASES**

Common Anesthetic Gases	• Nitrous Oxide • Halogentated Agents such as Enflurane, Chloroform, Halothane, Methoxyflurane • EH&S strongly recommends the substitution of ether with less flammable and less volatile anesthetic.
Potential Hazards	• Potential health hazards exist for exposure to trace gases. Symptoms include: nausea, dizziness, headaches, fatigue, and irritability, as well as sterility, miscarriages, birth defects, cancer, and liver and kidney disease. • Read the Material Safety Data Sheet prior to handling the chemical. • For additional information visit: **Controlling Exposure to Waste Anesthetics at UC Irvine** **(http://www.ehs.uci.edu/programs/ih/controllingwasteanesthetics.doc)**
Work Practices	• Any facility using anesthetics should institute and maintain a control program for waste anesthetic gases. • A complete waste anesthetic gas management program includes at the outset the application of a well-designed waste anesthetic gas scavenging system. Contact EH&S for assistance or visit: **Controlling Exposure to Waste Anesthetics at UC Irvine** **(http://www.ehs.uci.edu/programs/ih/controllingwasteanesthetics.doc)** • Open bench surgeries involving gaseous anesthetics should employ waste gas scavenging systems like snorkel exhaust devices. • Consult the Campus Veterinarians for appropriate selection of anesthetic agents.: http://www.research.uci.edu/ora/acup/veterinaryconsultation.htm. • When using low vapor pressure anesthetic agent like methoxyflurane, An anesthetic chamber (bell jar) may be used. Place the jar inside a fume hood to minimize employee exposures.
Exposure Concentrations	• No worker should be exposed to concentrations of waste anesthetic gases greater than 2 parts per million of any halogenated anesthetic agent. Controlled agents and their respective weights corresponding to 2 ppm are: chloroform, 9.76 mg/cubic meter (m^3), halothane, 16.15 mg/ m^3; methoxyflurane, 13.5 mg/ m^3; enflurane, 151 mg/ m^3; fluroxene, 10.31 mg/ m^3 • The occupational exposure to nitrous oxide, when used as the sole anesthetic agent, shall be controlled so that no worker is exposed at eight-hour time weighted average (TWA) concentrations greater than 25 ppm during anesthetic administration.
Spill Clean-up and Disposal	• Small spills of liquid anesthetic agents (<10 ml) evaporate readily and may dissipate before any clean-up attempt is initiated. • When large spills occur such as a bottle of liquid agent breaks, only equipped and trained personnel may clean-up the spill. Leave the area and contact EH&S. • All contaminated absorbent pads must be disposed of as hazardous waste.

Personal Chemical Storage

Personal chemical storage is available. They must be stored in proper containers then placed in double containment containers. The containers must have user name, date and the material or chemical stored in the container. Dates on the container must be updated every 180 days. This way the staff knows the materials are still in use. Any dates over 180 days will be removed and disposed of

General Acid Waste Chemical Storage

Users are required to collect all used chemicals. These containers are stored under designated wet benches. Containers are labeled with the waste material. If user does not find a container for the proper waste the user is responsible to generate a new container with the proper label. These must be stored in double containment. Check with staff if needing assistance.

Virgin Chemical Storage

Virgin chemical storage is located under designated wet benches. These containers are original manufacturer containers. Once user draws the material needed for research please return container back to its double containment container. Do not sit on the floor or leave on the bench. If chemical is used up or is getting low please inform staff. If user has need to bring in their own virgin chemical please check with staff before doing so.

Solvent Waste

Solvent waste containers are distributed at various locations in Wet etch and Lithography rooms. Pour only Acetone, Methanol, Alcohol and photo resist into these containers. Please use the funnel provided and return the container cap to the container. Place the container back to its double containment container.

Solid Solvent Waste

The steel waste containers are designated for solid waste. These are usually red or yellow and identified with flammable or solvent waste only labels. Use for clean room wipes, foil paper exposed to solvent material. If material is saturated please use individual trash bags before disposing into the waste container. Always make sure the container lid is completely closed when finished.

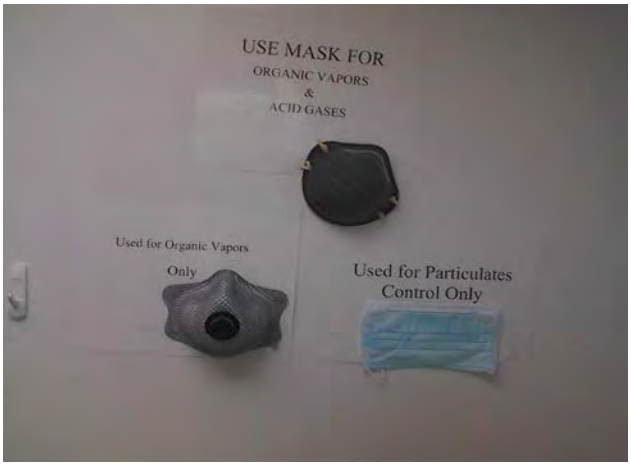
Solid Acid Waste

The plastic white containers are for solid acid waste only. Clean up wipe exposed to acid, any saturated item used to clean up small acid spills on bench tops or from extensive cleaning. Put in double containment bags before disposing of them. Make sure the lid in completely closed when finished. Check with staff if any questions.

Nitrile Safety Gloves

These are general use nitrile gloves. They are located in the gowning area and are required To be worn as a first level protection. If you are allergic to nitrile please notify staff.

Masks



The facility provides a general use particulate mask. It does not protect the user from Hazardous materials. The mask is to prevent particulate material from contaminating the device you are working on. Other masks are available. Check with staff for proper use and availability.

Sharpie Container

Sharpie containers are distributed throughout the lab. These are used for small pieces of broken glass and substrate material that should not be thrown into general trash cans.

Protective Gear (PPE) Equipment

Personal Protective Gear must be worn when using acids. Splash shield or shroud should be pulled down to the designated height when pouring chemicals into beakers.

(PPE) Equipment

Chemical resistant sleeves need to be properly worn. Sleeves need to be pulled over the glove to prevent any material to run down into the glove.

(PPE) Equipment

The lab provides MAPA chemical gloves, which are a Nitrile Glove 11 mil thick. They withstand most of our acids with different time Durations. Refer to the spreadsheet on page 76 for more information.

Used (PPE) Equipment

PPE is only good when it is in good condition. Please take the time to make sure the equipment is not damaged and put on correctly and the fit is comfortable before starting your task.

MAPA PROFESSIONAL

THE HANDS DOWN LEADER IN PROTECTION TECHNOLOGY

STANSOLV®/A-10

Description:
Unique Z-pattern grip provides an excellent grip, even on hard-to-grasp materials. The light weight A-10 provides outstanding dexterity and protection. against chemical and liquid permeation. Unique carboxylated MAPA nitrile compound contains no fillers and provides unsurpassed resistance to snags, punctures, abrasion and cuts. In compliance with 21 CFR 170-199 for food and drug handling.

Applications:
Plating, Chemical Processing, Meat and Poultry Processing, Degreasing Operations, Solvent Washing, Acid Etching

Product Specs:

Polymer:	nitrile	Thickness:	11 mil (0.28 mm)
Length:	13' (33 cm)	Color:	green or blue
Grip:	Z-pattern	Lining:	unlined
Cuff:	flat		

Ordering Information:

Catalog Number	Size	Unit of Measure	Case Quantity	Case Wt. Lbs.
470426-Green	6	PR	72	8
473426-Blue	6	PR	72	8
470427-Green	7	PR	72	9
473427-Blue	7	PR	72	9
470428-Green	8	PR	72	9
473428-Blue	8	PR	72	9
470429-Green	9	PR	72	10
473429-Blue	9	PR	72	10
470420-Green	10	PR	72	10
473420-Blue	10	PR	72	10
470421-Green	11	PR	72	11
473421-Blue	11	PR	72	11

Chemical Resistance Data

Glove Name - Polymer Chemical Name CAS Number	Conc.	Overall Chemical Protection Rating	Permeation Breakthrough Time Mins	Permeation Rate µg/cm²/min	Degradation % Wgt. Chg. (in minutes) 5	30	60	240	Puncture Rating
STANSOLV® / A-10 - nitrile									
1,1,1 Trichloroethane 71-55-6	95%	2	52	534.9	NT	E	NT	NT	1
1,1,2,2-Tetrachloroethane 79-34-5	98%	0	12.4	NRD	P	NT	NT	NT	
1,3 - Dichlorobenzene 541-73-1	99%	1	19.1	40.7	F	NT	NT	NT	0

1,3 Ethoxy propionate (Ethyl 3-ethoxypropionate) 763-69-9	99+%		76	174	NT NT NT NT	
1-Methyl-2-Pyrrolidinone 872-50-4	99%	1	21	239	F P P P	
2,2,2-Trifluoroethanol 75-89-8	99%	0	11	1283	P NT NT NT	0
2-Butoxyethanol (Butyl Cellosolve) 111-76-2	99%	4	250	1	NT NT NT F	2
2-Ethoxyethanol (Cellosolve) 110-80-5	99%	5	216.3	0.2	NT NT G NT	1
2-Ethoxyethyl acetate (Cellosolve Acetate) 111-15-9	99%		75.1	70.1	NT NT NT NT	
2-Propanol (Isopropanol) 67-63-0	99.5%	5	>480	ND	E E E E	
2-Pyrrolidine 123-75-1	100%		21	18	NT NT NT NT	
50% Arochlor 1254 (Chlorodiphenyl) in 1,2,4-Trichlorobenzene Mixture	50%		>180*	ND	NT NT NT NT	
Acetic Acid 64-19-7	50%	5	>480	ND	NT NT NT F	4
Acetic Acid (Glacial) 64-19-7	99%	2	43	ND	E G F P	
Acetone 67-64-1	99.5%	0	4	ND	F P P P	
Ammonium Hydroxide 1336-21-6	30%	5	440	0.2	E E E E	
Aniline 62-53-3	99.5%	1	30	7.5	F NT P NT	0
Aqua Regia 8007-56-5	Mixture	5	>480	ND	E E E E	
Bioact 115	Mixture		122.6	ND	NT NT NT NT	
Butyl Acetate 123-86-4	99%	2	44	332.4	E F F P	0
Carbon tetrachloride 56-23-5	98%	4	243.2	17	NT NT NT F	3
Chromic Acid 7738-94-5	50%	4	261.3	NRD	NT NT NT E	4
Cumene 98-82-8	98%	4	189.1	0.5	NT NT G NT	4
Cyclohexane 110-82-7	99%	5	>480	ND	NT NT NT E	4
Cyclopentanone 120-92-3	99%		6	169	NT NT NT NT	
Diethanolamine 111-42-2	97%	5	>480	ND	NT NT NT E	4
Diethyl Ether 60-29-7	99%	1	20.3	54.9	E NT NT NT	1
Dimethylsulfoxide(DMSO) 67-68-5	99.6%	1	53.4	11.6	G P NT NT	0
Ethanol 64-17-5	95%	3	92	21.7	NT NT E NT	3
Ethyl L -(-)- lactate 687-47-8	98%	3	152	117	NT NT F NT	2
Ethylene glycol 107-21-1	99%	5	>480	ND	E E E E	
Formaldehyde 50-00-0	37%	5	>480	ND	NT NT NT E	4
Furfural 98-01-1	99%	0	17	31.3	P NT NT NT	0
Heptane 142-82-5	99.5%	5	>480	ND	NT NT NT E	4
Hexamethyldisilazane (HMDS) 999-97-3	98%		>480		NT NT NT NT	
Hexane 110-54-3	95%	5	>480	0.0	E E E E	
Hydrazine 302-01-2	70%	5	>480	ND	NT NT NT E	4
Hydrochloric Acid 7647-01-0	37%	5	>480	ND	NT NT NT E	
Hydrofluoric Acid (Hydrogen fluoride) 7664-39-3	48%	4	200	>16	G F G F	
Isobutyl alcohol						

78-83-1	99%	5	>480	ND	NT NT NT E	4
Kerosene 8008-20-6	mixture	5	>480	ND	NT NT NT E	4
m-Cresol 108-39-4	97%	1	129.9	0.9	G P P NT	2
Methanol 67-56-1	99.9%	1	30	98.5	E E E G	
Methyl Isobutyl Ketone 108-10-1	99%	1	18.3	339	E NT NT NT	0
Methyl-3-methoxypropionate 3852-09-3	100%		28	88	NT NT P NT	0
Naphtha 8030-30-6	mixture	5	>480	ND	NT NT NT F	4
Nitric Acid 7697-37-2	70%	1	14.1	NRD	F NT NT NT	
Nitrobenzene 98-95-5	99%	1	17.4	4.8	F NT NT NT	0
Oleum 8014-95-7	67% free SO3		358	ND	NT NT NT NT	
Petroleum Ether (VM&P Naphtha) 8032-32-4	mixture	5	>480	ND	NT NT NT E	4
Phenol 108-95-2	saturated	2	111.4	4.7	NT G P NT	
Phosphoric acid 7664-38-2	85%	5	>480	ND	NT NT NT E	4
Polychlorinated Biphenyl			NT	NT	E E E NT	
Potassium Hydroxide 1310-58-3	50%	5	>480	ND	NT NT NT E	4
Propylene Glycol Methyl Ethyl Acetate(PGMEA) 108-65-6	99.5%	3	103	104	NT NT G NT	2
Propylene Glycol Monomethyl Ether 107-98-2	99.5%	3	111	52	NT NT E NT	3
Sodium Hydroxide 1310-73-2	50%	5	>480	ND	NT NT NT E	4
Sulfuric acid 7664-93-9	96%	0	110	ND	G P P P	
Tert. Amyl Methyl Ether 994-05-8	97%	5	>480	ND	NT NT NT E	3
Tetrachloroethylene (Perchloroethylene) 127-18-4	99%	5	>480	ND	NT NT NT F	3
Tetraethyl Orthosilicate 78-10-4	100%		>480	ND	NT NT E NT	4
Tetramethyl Ammonium Hydroxide 75-59-2	25%		>720	ND	NT NT E NT	4
Toluene 108-88-3	99.5%	1	10	>740.3	G P P P	
Triethanolamine 102-71-6	97%	5	>480	ND	NT NT NT E	
Trimethylphosphite 121-45-9	97%		23.7	0.1	NT NT NT NT	
Turpentine 8006-64-2	mixture	5	>480	ND	NT NT NT E	4
Unleaded gasoline 8006-61-9	mixture	5	>480	ND	NT NT NT E	4
Xylene 1330-20-7	98%	2	38	234	E F P P	

Overall Chemical Protection Rating

Protection rating is determined by taking into account the effects of both permeation and degradation in an attempt to provide users with an overall protection guideline when using our glove products against specific chemicals

- 0 For Splash Protection Only, change glove immediately when chemical contacts glove
- 1 Change glove after 5 to 30 minutes of exposure to chemical
- 2 Change glove after 31 to 60 minutes of exposure to chemical
- 3 Change glove after 61 to 180 minutes of exposure to chemical
- 4 Change glove after 181 to 300 minutes of exposure to chemical
- 5 Change glove after 301 to 480 minutes of exposure to chemical

ASTM F739 Permeation Key

NT = Not Tested
ND = None Detected
NRD = No Rate Determined
$\mu g/cm^2/min$ = Micrograms per square centimeter per minute
> Greater than
< Less than

ASTM D471 Degradation Key

Weight Change	Performance Rating
0 - 10%	Excellent
11 - 20%	Good
21 - 30%	Fair
Over 30%	Poor

ANSI/ISEA 105-2000 Puncture Degradation Key

Level 0	greater than 80% Change in puncture
Level 1	less than or equal to 80% Change in puncture
Level 2	less than or equal to 60% Change in puncture
Level 3	less than or equal to 40% Change in puncture
Level 4	less than or equal to 20% Change in puncture

*Non-Normalized Breakthrough.

The chemical test data and overall chemical protection rating should not be used as the absolute basis for glove selection. Actual in-use conditions may vary glove performance from the controlled conditions of laboratory tests. Factors other than chemical contact time, such as concentration and temperature, glove thickness and glove reuse, may also affect performance. Other glove requirements, such as length, dexterity, cut, abrasion, puncture and snag resistance, or glove grip also need to be considered in making your final selection.

Chemical Utensil & Hot Plates

Some of the standard wet benches are identified with utensils and hot plates. These are for general use. Upon using make sure utensil is clean before using and cleaned after use and returned to the proper cabinet.

Chemical Utensil Beakers Plastic / Glass

General use glass/plastic beakers are stored in plastic tubs. Make use you use the proper container compatible with the material in use. Upon finishing clean container and return to proper bin.

Standard" Wet Bench

Standard wet benches are used for general purpose processes. These are polypropylene benches and highly flammable. Anytime hot plates are used on these benches they must be attended at all times. These benches are equipped with DI and domestic water. They have a Nitrogen blow off gun and hand held eyewash located in the upper left hand corner of the bench. Decks of benches must be cleaned after completion of work.

Non-Standard" Wet Bench

Nonstandard wet benches have built in standard heating wells that are temperature controlled and rinse baths. Baths are used for KOH or Piranha or RCA-1 or RCA-2 cleaning. The rinse baths are constant DI water flow using Nitrogen for aspiration.

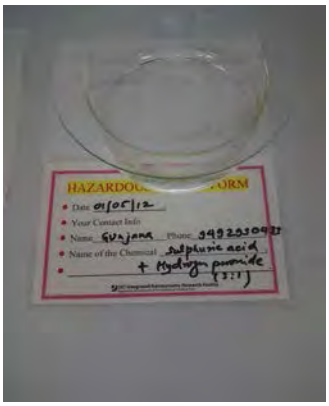
" Solvent" Wet Bench

Solvent benches are designated to perform processes that deal with flammable material. These benches are equipped with deep wells with temperature control hot plates and rinse sink with DI water and Nitrogen blow off guns. No materials should be poured down the drain. All waste material must be collected.

"Standard" fume Hood

Standard fume hoods are the only hoods not equipped with laminar flow capability. These benches are used for standard chemistry such as setting up electroplating stations. They are not equipped with Nitrogen blow off guns or rinse stations. Upon finishing work clean up station and safely store any materials that were used.

Chemical In-Use Form



The lab provides the chemical in-use forms which are reusable. They are located in holders mounted within rooms where chemical are used. Forms should have Name, Cell number, E-mail address, Chemical being used and Date. Use a black Sharpie marker to input the information and when finished clean with an alcohol clean wipe and place back in holder.

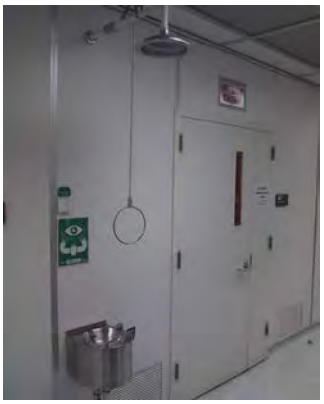
Chemical In-Use Form "Over Night"

Sometimes it is necessary to have chemicals cool down or finish reacting before returning to personal storage containers or disposing into waste containers. Please reflect this in the comment area of the in-use form so other users and staff are aware.

Eye Wash on " Standard " Wet Bench

Standard wet benches are equipped with eye wash that uses domestic water. These are not rinse guns with DI water and are not to be used to wash off substrates

Eye Wash and Shower in Main Hallway



There are two eye wash and showers that are located at each end of the main hall. These are used for major chemical exposure. Please make note of their location.

Eye Wash in Main Hallway

This is an image of the eyewash located in the main hallway. One is located outside the developing room and one outside the wet etch area.

Eye Wash on slate Benches and Sink

There are four hand held eyewashes located on slate workbenches. One by the standard fume hood where electroplating stations are set up. One by the wire bonding station, one by the lapping /polishing station and one by the chemical waste room.

Transporting Chemical Bottle

When transporting chemicals from one room to the next it is required you use a chemical carrier.

Chemical Bottle Carrier

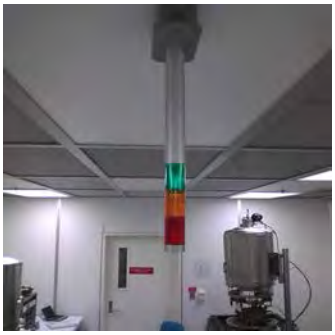
There are two different sized chemical carriers. Please use the appropriate size carrier to make sure the bottle stays upright

First Aid Boxes

There are two first aid boxes located in the BiON and INRF. One box outside the wet etch area and one box located at the opposite end of the lab. Both are in the main hallway. These boxes consist of:

Clean Alcohol Wipes
Triple Antibiotic Ointment
Flexible Finger Tip Bandage
4''X 4'' Sterile Gauze Pad
2''X 2'' Sterile Gauze Pad
Antiseptic Bacterial Virucidal Pad
Band Aids
Roll Gauze
Calcium Gluconate Gel

Light indicator Reactive gas Level



The lab is equipped with an automated reactive gas alarm system. Once activated these indicator wands will illuminate. Green – good, Yellow – warning, Red – evacuation. They are located in rooms where reactive materials are being used, such as dry etch, and oxidation furnaces.

Gas Detection System For Combustibles

This is one of our combustible gas detection systems. This system detects Hydrogen and Methane. It is located in the oxidation furnace area. Once these gases are detected the light indicators will go red and an audible alarm will sound. Evacuate area and notify staff.

Emergency off For Reactive gas and Power

These are EPO (emergency off switch). The larger one will shut down combustible and reactive gases. The smaller one labeled AC emergency off switch will shut down all the utility power is that adjacent room. These switched are designated for that adjacent area. Other emergency switches are located throughout the lab.

Combustible Gas in Use in Room

These signs are above the doors that combustible and reactive gases are being used.
This is a visual notice so users know combustible gases are in use.

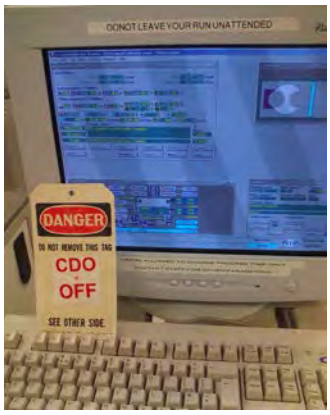
Exhaust Alarm for Laminar Flow Bench

There are visual and audible alarms for different types of exhaust hoods. This type is located on the standard wet benches. There are other types for the solvent benches, dedicated benches and fume hoods. Be familiar with their location and operation of these alarms.

Inches of water Exhaust Alarm

These alarms are located on top of standard wet benches. They are very important as they tell you if the exhaust system is insufficient or the exhaust is turned off due to the system not functioning properly. If the alarm activates lower the sash below its indicating mark, turn off any hot plates cover any material presently in use and notify staff.

Equipment tag out



There are different types of tag outs for the equipment. This tag out indicated that the pollution control device has not been turned on or has not come up to temperature. Usually this tag is put in place by staff and removed by staff once the tool is useable.

Equipment Lockout tag out

This tag indicates the tool is either in repair or being serviced for maintenance. Staff or user can place this tag to tag out this tool. Only staff can remove the tag. Once tag out is placed please note information in log book and notify staff of placement of tag.

Gas In-Use tag

These tags are used to indicate which reactive gases are turned on and which reactive gases are turned off. These are located in the various equipment chases. It is recommended the user goes into these chases to verify that the gases they plan to use are in the on state and gauges are reading the proper pressure before using the tool.

In use and Lockout cylinder donuts

Users need to be aware that there are multiple cylinders of the same gases within the equipment chase that support different tools. Some of these tools require a certain gas to perform the proper chemical reaction to make a safe process. If one of these gases get turned off it could cause a unsafe process. Users need to be aware of safety donuts located on top of the cylinder. These donuts are also used to lockout process gases.

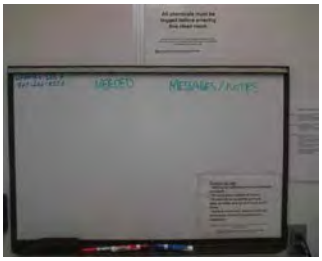
Pollution Control Device INRF

This is a typical pollution control device (CDO) located in the INRF. These systems should be functional before performing any processing of equipment these units support. There are three units throughout the lab. Be familiar of their location.

Pollution Control Device BiON

This a newer type of pollution control device (CDO) system but performs the same function. This one is located in the BiON. Be familiar of its location before performing any work.

Lab Message Board



The lab message board can be used for multiple purposes. It is a way for staff to post information for users. Also users can use this to communicate with staff, such as low on lab materials so they can be replenished, or any items pertaining to the lab. These boards are located in the pre-gowning area, one in the BiON and one in the INRF.

Standard Operation Procedure

Optical fiber etching with HF

Description

This SOP addresses the work performed to chemically etch the optical fibers using the 48% stock HF with an overlayer of silicone oil. The fibers can be either with the cladding or without the cladding. This SOP also addresses removal of waste chemicals, cleaning of equipment, and handling of these chemicals.

Required Safety Equipment & Personal Protective Equipment (PPE)

The 48% HF exposure can cause severe burns or death even in small amount. The person who performs the work with HF **MUST** read the MSDS of HF before starting the work. During the process the person also needs a company for help in the case of HF splashing on the body and/or the clothes.

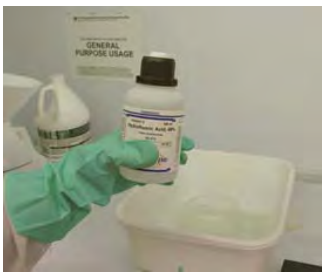
HF handling requires the use of safety equipment and chemically compatible personal protective equipment including

- Designated ventilation hood
- Latex gloves
- Large green nitrile gloves
- Green nitrile sleeves
- Green nitrile apron
- Splash-proof safety goggles

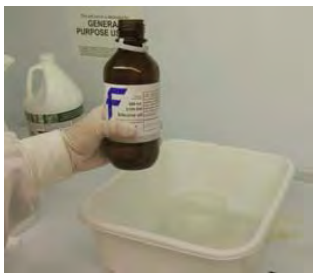
Procedures / Steps Needed To Complete Work Safely

- Sample setup
  a. Mount the fibers to a holder. b. Fill a container with the de-ionized water.

B. HF Setup
  a. Put on all PPE in preparation to handle HF.
  b. Make sure that the fume hood is ventilating
  c. Place a HF container (usually a polypropylene beaker) in a plastic dish.
  d. Carefully pour the 48% stock HF into the HF container (20-40 mL) to avoid the splash.



e. Slowly pour the silicone oil to the HF container (5-10 mL). Make sure that the silicone oil covers the whole surface of HF.



C. HF etch

a. Adjust the height of the fiber holder so that a desired depth of the fibers could be immersed under the surface of the HF/Silicone oil.
b. Dip the fibers into the HF.
c. Remove the fibers from the container after a desired amount of time.

D. Rinse

a. Place the fibers in the de-ionized water container.
b. Rinse for 10 minutes in the de-ionized water.

E. Dispose the HF/Silicone oil waste

a. Put the HF/Silicone oil into a plastic waster bottle.
b. Clean the HF container with ~50 ml 5-10% of Simple green.

c. Swirl and rinse the funnel with the same Simple green in the HF container.
d. Rinse the HF container and the funnel with the de-ionized water.

F. Fiber removal

a. Remove the fiber from the de-ionized water container.
b. Rinse the water container with the de-ionized water.

APPENDIX B

READ AND REVIEW ANY APPLICABLE MANUFACTURER/VENDOR MATERIAL SAFETY DATA SHEET (MSDS) INFORMATION BEFORE DEVELOPING STANDARD OPERATING PROCEDURE AND PERFORMING WORK.

PI Name: _____

Dept/Section Name of Work Unit:_____

Standard Operating Procedures for Hydrofluoric Acid

#1	Scope of Work/Activity: State the process/operation/equipment that the SOP concerns.
#2	Specific Safety and Environmental Hazards: State the specific hazard and consequences if procedure not followed to person, environment, or property. Review MSDS prior to working with any hazardous material. Acute effects of HF exposure include extreme respiratory irritation, immediate and severe eye damage and pulmonary edema. Skin, eye, or lung exposure to concentrated (~50%) HF solutions will cause immediate, severe, penetrating burns. Exposure to less concentrated solutions may have equally serious effects, but the appearance of symptoms can be delayed for up to 24 hours. **If you are exposed to hydrofluoric acid seek medical attention immediately, even if you do not feel pain** Pure HF etches glass. Secondary containment trays constructed of polypropylene must be used Check container compatibility at: http://www.coleparmer.com/techinfo/ChemComp.asp .***Never use Hydrofluoric Acid when working alone or after hours.*** Label containers with contents and indicate: **Corrosive. Wash contaminated areas and apply antidote on skin. Seek medical attention.**

#3	Engineering Controls: Describe any specific engineering controls which are required to prevent employee injury to hazards such engineered sharps, bio safety cabinet, fume hood, etc. All HF activities must be carried out inside a chemical fume hood with calcium gluconate antidote gel nearby. Verify that the fume hood has been certified in the last year. Example on page 85.
#4	Designated Area: Indicate the designated area for performing this process in the laboratory.
#5	Personal Protective Equipment (PPE): State the personal protective equipment selected and required. Skin protection, chemical splash goggles and face shield, when needed. Recommend Best Neoprene Gloves or Silver Shield. Check glove permeation guide chart: http://www.coleparmer.ca/TechInfo/GloveChemComp.asp http://www.showabestglove.com/site/products/whatsthebestgloveforme.aspx Avoid inhalation of fumes. Use only inside a fume hood. Users will wear lab coat, neoprene apron, extra length chemical gloves and full face shield with chemical splash goggles underneath.
#6	Important Steps to Follow: List the specific sequence staff should follow to avoid hazard. Storage- The stock HF should be stored in plastic secondary containment and the cabinet should be labeled. HF should be stored in lower cabinets near the floor. Use a plastic tray while working with HF for containment in case of spill. Keep containers closed. HF can etch the glass.

#7	Emergency Procedures: Describe immediate medical treatment required in case of personnel exposure. -Complete online incident report form at www.ehs.uci.edu First Aid: Remove contaminated clothing and shoes while flushing with water. Get medical attention immediately. Eyes: wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, at least 15 minutes. Skin: wash affected area with soap or mild detergent and large amounts of water for five minutes. Rinse scalp and areas underneath skin folds thoroughly. Apply calcium gluconate gel by rubbing it gently into the affected area. Inhalation: remove to fresh air immediately. **Seek medical attention even if you don't feel the pain when exposed to any HF.** Before beginning work involving HF an exposure kit must be available and located in the laboratory area. The exposure kit must contain the following items: 1. Container of calcium gluconate gel. This gel must be inspected before each use of HF or at least monthly to ensure the gel has not been removed or has not reached the ***expiration date***. If a tube of the gel has been opened, a new container must be purchased and the old container discarded. No work with HF can be done with an expired tube of calcium gluconate gel. 2. Stanolv Neoprene (11mil) gloves. 3. One heavy-duty polyethylene bag to be used for items contaminated by HF. 4. One HF Contaminated Waste Label. 5. Copy of these procedures and MSDS to take to the emergency room.
#8	Identify waste stream and disposition of waste, and unused stock of chemicals (Identify if waste is biohazardous, pathological waste, or hazardous waste, etc.) Additional guidelines regarding hazardous waste and pathological waste can be found at: http://www.ehs.uci.edu/programs/enviro/ • Surplus chemicals will be disposed of as hazardous chemical waste. • Obtain waste containers from EH&S. • Sharps will be disposed of in "Sharps" container. • At Irvine locations, utilize the on-line system for requests by requesting a "Chemical Waste" Pickup via the Internet: Visit www.ehs.uci.edu/programs/enviro/

#9	Decontamination and spill clean-up procedures Make sure chemical spill kit is readily available. Small spills: Do not attempt clean-up if you feel unsure of your ability to do so or if you perceive the risk to be greater than normal laboratory operation. Neutralize contaminated surface. Collect residue and contaminated wipes into hazardous waste container. Label and transfer to EH&S for disposal. Large Spills: Notify others in the area. Evacuate room and notify EH&S. Contaminated areas should be neutralized and cleaned thoroughly with soap and water and pH should be checked. All waste generated in this process should be placed in hazardous waste containers and labeled to indicate the presence of hydrofluoric acid.

As the Principal Investigator, it is your responsibility to ensure that all individuals listed in this protocol are taught the correct procedures for the safe handling of hazardous materials involved in this study. It is also your responsibility to assure that your personnel attend Lab Core Safety Training and other applicable safety training courses.

Both PI and all persons associated with the protocol must sign the following acknowledgement:

I have read, asked questions, and understand the hazards of and safe working procedures for the activity/materials described herein.

_____

PI Signature: Date

Other Personnel:

_____

Name/ Signature Date

_____

Name/ Signature Date

_____

Name/ Signature Date

_____

Name/ Signature Date

UCI Integrated Nanosystems Research Facility
Engineering the Microworld at The University of California, Irvine

SAFETY COMPLIANCE FORM

THIS FORM MUST BE COMPLETED BY ALL USERS OF INRF and BiON

To ensure safety for all users of the INRF and BiON Cleanroom Facilities, we require that all users complete safety training which includes the following steps listed below. The required safety documents and training contain important information on potential hazards that can exist in a cleanroom setting and how to limit your exposure and risk.

1.) Read & Study the following documentation (found on INRF Website at: http://www.inrf.uci.edu/?page_id=233, hard copies are also available in the INRF Office):
   a. INRF Chemical Hygiene Plan
   b. INRF Laboratory Safety Manual
   c. MSDS Literature

2.) Attend:
   a. New User Orientation
   b. UCI EH&S Safety Training
      i. Labatory Core Safety
      ii. Hazardous Waste

After completion, User is encouraged to ask INRF Staff members questions to ensure comprehension of safety documentation. This form is required in order to become a user of our cleanroom facilities. Please sign this form and submit with EH&S Safety Training certification to INRF Staff.

User Acknowledgement and Agreement:
I acknowledge that I have read and understand the INRF Safety Documentation listed above and have attended the Orientation Presentation and completed the EH&S training. I am aware of potential hazards that exist in the lab and have been informed of the necessary precautions to take to limit risk. This includes (but is not limited to) exposure to a number of very toxic materials, such as hydrogen, dichlorosilane, ammonia gases, solvents and acids, and pieces of high voltage equipment. For my personal safety, I agree to wear a pair of safety glasses or chemical splash goggles which conform to the ANSIZ87.1-1989 standard at all times when inside the INRF and/or BiON clean room areas. In addition, I agree to follow all INRF and BiON safety polices and equipment operating procedures.

I understand that violation of safety policies and procedures will lead to the following disciplinary action:
1. Verbal warning to the violator by INRF and/or BiON staff member
2. Letter to the violator's advisor or supervisor
3. Suspension of access to the INRF and/or BiON for a period of one month
4. Permanent loss of access privileges

USER Name:_____Title:_____

Signature: _____Date: _____