
# NanoFabrication Facility Safety and Standard Operating Procedures

## Safety Policy Statement

The management and staff of the Center for Optoelectronics and Optical Communications Nanofabrication Facility have implemented a variety of measures to ensure a safe working environment. It is however the responsibility of all certified users to follow all safety and standard operating procedure (SOP) rules while in the facility. Failure to do so can endanger the user, fellow workers, or the facility. Infractions will be handled on case by case basis and may result in the loss of privileges. Copies of this document have been provided to each facility user. A copy of this document can be found in the gowning room and is provided on-line at the Center for Optoelectronics and Optical Communications web-site (http://opticscenter.uncc.edu/facilities).

## EMERGENCY NUMBERS

**For Medical Response:**

**911**

**For chemical spills, facility issues, etc.:**

| | | |
|---|---|---|
| **Bruce Dudley** | **704-687-8180 (office)** | **704-807-8852 (mobile)** |
| **Lou Deguzman** | **704-687-8111 (office)** | |
| **Alec Martin** | **704-687-8142 (office)** | **704-460-0481 (mobile)** |
| **Scott Williams** | **704-687-8126 (office)** | **336-255-2277 (mobile)** |

The following steps must be completed to gain and maintain access to the Optics **N**anoFabrication **F**acility (ONF) and the equipment contained within:

- **Access to ONF**
  Review the ONF Safety and SOP Manual.
  Pass the ONF Safety and SOP test.
- **Access to Equipment**
  Train with a certified user in ones own group.
  Train with an ONF staff member.
  Contact ONF staff for certification.

## Standard Operating Procedures

**General Guidelines**

It is the responsibility of each certified user to maintain a safe and clean work environment. Clean up your area once you are finished processing. Workspace is extremely limited within the ONF. Do not leave chemicals, samples, materials, notebooks in the work area once processing is completed. Storage of such items is provided for in other areas of the ONF. Chemicals must be stored in the appropriate chemical storage cabinets or disposed of in the appropriate manner. Samples, materials, notebooks, etc. may be temporarily stored on the shelving units located in the facility corridor. Proper gowning protocol must be adhered to at all times within the facility to maintain cleanliness. The ONF is available to certified users both day and night and weekends. Certain restrictions though will apply. You are not permitted to work alone if your work involves the use of any chemicals, e.g., acids, bases to include developer solutions, etc. The use of pyrophorics (silane) will be limited to weekdays between the hours of 8:00 am and 12:00 pm, unless prior approval has been granted by the ONF clean room manager.

**Equipment Usage**

Granted access to the ONF doesn't necessarily allow equipment access. Most of the ONF equipment is highly sophisticated, expensive to maintain, and extremely delicate. Only certified users are permitted to operate ONF equipment. Equipment training is provided by either certified users or by ONF staff. After the individual has received training, certification will be conducted by ONF staff. Once certified the individual is granted permission to operate that particular instrument without supervision. Appendix B provides additional detail as to the use and operation of ONF equipment.

**Visitors**

Prior approval must be obtained from the ONF clean room manager before a visitor will be granted access to the ONF facility. A visitor is characterized as any individual that has not received the required ONF Safety and SOP training leading to certification. This includes UNC-C faculty, staff, and students as well as representatives from companies and other institutions Dangerous chemicals, gases and equipment are used in the facility so it is imperative that any visitor be escorted by a certified user while in the ONF clean room.

**ONF Clean Room Attire**
The following must be worn at all times while in the ONF clean room:

- Bouffant (hair net) required for shoulder length hair and longer.
- Hood
- Face Shield
- Coverall
- Shoe Cover
- Gloves
- Safety glasses (removal is permitted while using microscopes)

New Clean Room garments are stored in lockers located in the ONF gowning room. After one week of use or if soiled, place used garments in the soiled garment bin located in the ONF gowning room. The soiled garments are sent to a processing facility for cleaning and returned to the ONF for future use.

Clean Room attire should be donned using the following sequence:

1. Bouffant (hair net) – required for shoulder length hair and longer
2. Hood
3. Face Shield
4. Coverall
5. Shoe cover
6. Gloves
7. Safety Glasses

Prior to entry make sure the hood is completely tucked in the coverall, coverall sleeves are positioned over the glove sleeve, and all hair is contained within the bouffant and/or hood.

**Contamination Control**
People are the biggest source of contamination within the ONF Clean Room. Skin flakes, hair, and fibers shed from your clothing present the greatest threat to the cleanliness of the ONF clean room. The clean room attire when properly worn trap the majority of these particles, so it is absolutely imperative that the clean room attire be worn at all times while in the ONF clean room.

Note: sandals, open toe shoes, and shoes with heels greater than 2” are prohibited within the clean room facility. Never bring pencils, erasers, cardboard boxes, packing material, backpacks, food, drinks, gum, or anything that is not absolutely necessary for the intended activity. ONF approved clean room notebooks and ball point pens are permitted.

Tools and equipment should be wiped off using clean room wipes and isopropyl alcohol prior to entry. These items can be brought in through the air lock or mechanical chase room 384.

**De-ionized (DI) Water**
The two chemical processing hoods contain de-ionized water rinse tanks. These tanks are used for the rinsing of substrates and substrate processing materials, e.g., beakers, wafer holders, containers, tongs, etc. DI water is a finite source so always turn off the DI water flow to the cascade rinse tank when finished. The hood reserved for processing acids and bases has additional filter units to provide 18 Mohm water. The resistivity of the DI water in the solvent processing hood is approximately 1 Mohm.

**Vacuum**
Several lithographic systems require vacuum for holding wafers during processing. This vacuum is provided by several different vacuum pumps housed in two mechanical chases. The Imprio NanoImprint Lithography Systems has its' own dedicated vacuum pump which is located in mechanical chase room 370. The power switch for the Imprio vacuum pump is located on the clean room wall near the Imprio 100 system. The two Quintel Mask Aligners and the GCA DSW share a vacuum pump that is located in mechanical chase 370. The power switch for this pump is on the wall near the Quintel Mask Aligners. The convection vacuum oven has a dedicated vacuum pump housed in mechanical chase 374 and the power switch is on the clean room wall near the oven. The spin processors use vacuum for holding the wafer on the chuck while spinning. The vacuum pump for these systems is housed in mechanical chase room 374. The power switch is located on the wall just to the left of the spin station. Always turn off the power to the vacuum pumps once processing is completed. Since three of the lithographic systems share one vacuum pump, always check with other users before turning off the power to the DSW or either Mask Aligner in the event the other systems are in use.

**Facility Nitrogen**
Nitrogen is provided to the ONF clean room from the liquid nitrogen ($LN_2$) storage tank located near the loading dock. The $LN_2$ tank is a source of high purity dry nitrogen that is used for pump purges, pneumatic actuation, chamber venting, and $N_2$ guns. The $N_2$ supply pressure is 80 PSI. The bulk storage tank also has a fill station for the dispensing of $LN_2$. Once properly trained, individuals are provided with access to fill, transport, and use $LN_2$ within our facility. Hazards include asphyxiation (suffocation) since the tank is housed in a confined space, and sever burns. Skin contact with liquid nitrogen can cause tissue freezing, resulting in severe burns. The burns are caused by the extremely low temperature of the cryogenic liquid and not the result of chemical action. Cryo gloves and safety glasses should be worn whenever working with $LN_2$.

**Compressed Dry Air (CDA)**
CDA is supplied to the ONF clean room at a pressure of 90 PSI. CDA is used primarily for pneumatic actuation.

**Process Chilled Water (PCW)**
PCW is supplied to the ONF clean room at a flow rate of 15 gpm and a temperature of 45 to 50 degrees F. PCW is used in conjunction with water cooled system chillers for cooling vacuum pumps, RF components, and process chambers.

## Safety Guidelines

Safety is paramount! All activities conducted in the ONF clean room must be done in accordance with the safety rules. Failure to do so can compromise the safety of the individual user, fellow workers, or even the facility and can result in loss of clean room privileges.

**Material Safety Data Sheets (MSDS's**) are available for every chemical used in the ONF clean room. The chemical MSDS contains important safety information and should be reviewed prior to the use of any chemical for the first time. The MSDS is a document that summarizes the chemical composition, potential physical and health hazards, etc. An example of a representative MSDS is provided as appendix A. Copies of the chemical MSDS can be found in the ONF gowning room, the office of the ONF clean room manager, or the office of the ONF safety officer. An MSDS may contain the following terminology to more fully describe the hazards or properties of the chemical:

- **Flammable** – liquid chemicals that have a flashpoint below 100 degrees F. Flash point is the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. The lower the flash point, the easier it is to ignite the material. Examples of flammable liquids include acetone, methanol, and isopropyl alcohol. Certain gases such as hydrogen are flammable when mixed with air.
- **Corrosive** – chemicals that can cause irreversible tissue damage on contact. Most strong acids or bases are examples of chemicals that are corrosive.
- **Pyrophoric** – gaseous chemicals that can ignite spontaneously upon contact with air. Silane is pyrophoric in certain concentration levels. The silane concentration used in the ONF is classified as pyrophoric.
- **TWA or TLV (time weighted average or threshold limit value)** – the limit of exposure that is still considered safe 8 hours per day, 5 days per week for an average working lifetime.
- **STEL (short term exposure limit)** – the maximum exposure limit allowable for a short period of time (15 minutes, up to 4 times per day) without adverse physical or health effects.
- **PEL (permissible exposure limit)** – regulatory limits on the amount or concentration of a substance in the air
- **LD 50 (lethal dose)** - the amount of a substance, given all at once, which causes the death of 50% (one half) of a sample group.
- **IDLH – (immediately dangerous to life and health)** – an exposure level that can cause irreversible, or severe health effects, or loss of life.
- **Carcinogen** – a substance that can produce cancerous growth upon exposure.
- **Mutagen** – a substance that can result in mutations with exposure.
- **Teratogen** – a substance that is harmful to the unborn fetus.

**Compressed Gases**

The ONF clean room uses several compressed gases, some of which are toxic, corrosive, flammable, or explosive. Gas cylinders are pressurized which presents additional hazards

given the stored energy. A sudden escape of gas in an uncontrolled manner can result in a catastrophic incident. Therefore all gas cylinders are secured to stationary objects such as mechanical chase walls, or within gas cabinets. The hazards associated with the use of these gases has been mitigated through the use of supplemental ventilation, proper confinement, gas detection, automated shut-off valves, and certain procedures implemented by ONF management. A toxic/flammable gas detection system has been installed to provide early warning of a gas leak. The Beacon 800 multi-channel receiver/controller system modules are located in the ONF gowning room. Each receiver is capable of monitoring 8 different sensor inputs simultaneously. The individual sensors are located though out the ONF facility. Remote gas sensors are placed in the appropriate gas storage cabinets, system gas distribution cabinets, and near the operator stations. In the event of a gas leak the Beacon 800 receivers will sound a 94dB audible alarm and will trigger the flashing red strobe lights installed throughout the ONF clean room. The red strobe lights are located in each clean room bay, each clean room mechanical chase, and in the interior clean room corridor. In the event of a gas leak exit the ONF clean room immediately using either the gowning room or one of the mechanical chases located at either end of the clean room. Don't take time to remove your clean room garment – just exit!

**Liquid Chemicals**

The ONF clean room has a variety of liquid chemicals that are used for processing. These chemicals are typically classified as solvents, bases, or acids. All chemicals used in the ONF clean room should be considered hazardous. The hazards include but are not limited to severe burns, tissue damage, kidney and/or liver damage, and should be handled in accordance with the proper safety protocol which follows:

- Approval must be granted by either the ONF cleanroom manager or the ONF safety officer prior to purchase and subsequent use of any new chemical.
- All chemical processing must be done in an exhausted wet bench.
- Metal tweezers are incompatible with strong acids and bases – use only Teflon® PFA tweezers with these chemicals.
- The use of hotplates for heating chemicals is extremely dangerous and is highly restricted to the following criteria: 1) the heated chemical must never be left unattended; 2) only chemicals with a flashpoint above 140 degrees F (class III combustible liquids) may be heated using a hotplate; 3) never heat an exothermic (reactions that release heat) solution such as "Piranha" (sulfuric acid/hydrogen peroxide); 4) prior approval must be granted by either the safety officer or clean room manager prior to hotplate use.
- Processing of acids or bases should only be conducted in the wet bench adjacent to the resist spin station. Solvent processing should only be done in the wet bench adjacent to the Imprio 100. The segregation of these classes of chemicals is due to the incompatibility between acids/bases and organic solvents. For example, nitric acid combined with a common organic solvent may result in fire!
- All chemicals must be stored in the proper storage cabinet, i.e., acids and bases in the white polypropylene cabinets, and solvents in the yellow steel cabinets.
- Rubber apron, chemical resistant gloves, and safety glasses must be worn when chemicals are being transported, or used. The only exception to this rule is for the

cleaning of wafer backsides of residual resist using wipes or swabs treated with the appropriate solvent, e.g., acetone, IPA, etc, or when coating wafers with a photoresist.

- Note: one of the solvents, n-amyl acetate (pentyl acetate) which is used in our facility is classified as **Teratogenic** – "*harmful to the unborn fetus in exposure levels that are maternally toxic."* Cresol (also classified as a Teratogen) and n-amyl acetate, are also found in a few of our photoresist products, e.g., **Microposit S1813, SPR 220-7.0, JSR NFR-015, etc**. Although these materials when used properly in an exhausted fume hood should be relatively safe, disposable particulate respirators with activated carbon are available for use by those harboring concerns.
- Transport chemicals using either the polypropylene chemical cart or the low density polyethylene bottle carriers.
- When pouring chemicals into either a processing container or into the appropriate waste disposal container a protective face shield should be worn to protect against splash hazards. This is to be worn in addition to the normal safety attire, e.g., rubber apron, chemical resistant gloves, and safety glasses. Pour chemicals slowly to prevent splashing.
- Any chemical that is stored in non original containers or is in use must be properly labeled. Each sample container or process container must have the name of the user, the name of the chemical, and the current date. This is not only an OSHA requirement, it is necessary for waste disposal due to chemical incompatibilities, i.e., solvents should never come in contact with acids/bases. The mixing of organic solvents with certain acids can result in either an explosion or fire. HF acid should be disposed of separately due to its' incompatibility with certain strong acids and bases, e.g., sulfuric acid, sodium hydroxide, etc.
- Never dispose of chemicals using the wet bench drain. All chemicals should be disposed of using the appropriate waste disposal carboy – ask if you're not sure! There are four carboys located adjacent to the acid/base wet bench. One is for HF acid containing solutions only, one is for bases or developer solutions only, one is for piranha solutions only, i.e., sulfuric acid, hydrogen peroxide, and one is for all other acid solutions, e.g., nitric acid, hydrochloric acid, phosphoric acid, etc. Note: Used metal etches, e.g., aluminum etch, chromium etch, gold etch, etc. should be disposed of using a previously rinsed chemical bottle. An empty/rinsed chemical bottle can be found on the clean room shelf within the clean room corridor. Waste containers should be labeled "Metal Etch Waste", along with the metal etchant, your name, the current date, and placed in the acid/base chemical storage cabinet. The ONF staff will coordinate the disposal of this chemical
- There is also one disposal carboy located adjacent to the solvent wet bench. Use this carboy to dispose of organic solvents. All chemicals should be disposed of as soon as you're finished processing. The only exception is for chemicals that are exothermic or heated, e.g., Piranha, NMP, etc. Allow these chemicals to cool to room temperature before disposal. Rinse all process hardware, e.g., beakers, tongs, graduated cylinders, etc. and place in the storage areas – wet bench deck space is extremely limited.

- Expired or empty resist bottles should be placed in the bottom of the yellow solvent cabinet located in the clean room corridor. The ONF staff will coordinate the disposal of these containers.
- Empty chemical bottles (except for containers containing resist materials) should be rinsed and stored using the following procedure:
    1. Fill the empty bottle 1/3 full with DI water, replace cap, and shake.
    2. Empty into wet bench sink.
    3. Repeat steps 1 and 2.
    4. Once rinsed, write, "rinsed" on the bottle, your initials and the current date.
    5. Place on the clean room shelf located in the clean room corridor for future use as waste containers for metal etchants.

**Emergency Response Guidelines**

- First aid kits are located in each clean room bay, the clean room corridor and mechanical chase number 384.
- An emergency safety shower and eyewash station is located in the photolithography bay – familiarize yourself with its location before doing any liquid chemical processing for the first time. In the event of chemical exposure, the affected area should be rinsed for at least 20 minutes before seeking additional medical attention by calling 911. If exposed to any HF acid solution, calcium gluconate located in the first aid kits should be applied to the affected area after rinsing for 20 minutes.
- Small chemical spills (less than one liter) can be contained using the materials found on the spill kit carts. The two spill kit carts are located in the clean room corridor adjacent the liquid chemical processing areas. One cart is for organic "solvent" spills, e.g., acetone, resist, NMP, etc. The other spill cart contains materials used for "acid" and "base" solutions. Confine the spill to a small area using spill pillows or absorbent wipes. Alert other individuals in the immediate area. Attend to injured or exposed personnel. Avoid breathing vapors. Notify ONF staff immediately by calling the posted emergency numbers posted in the Safety and SOP manual located in the gowning room. Once contained, wait for ONF staff to arrive for final clean up and to provide details as to nature of chemical accident, chemical involved, quantity, personnel affected, etc.
- Large chemical spills (more than one liter) should **not** be contained using the materials found on the spill cart. Instead evacuate the clean room, attend to injured or exposed personnel, notify ONF staff immediately by calling the numbers posted in the Safety and SOP manual located in the gowning room, provide details as to nature of chemical accident, chemical involved, quantity, personnel affected, etc.
- Broken wafers or glassware should not be placed in the regular trash receptacles. Instead broken glassware or wafers should be placed in one of the, "Broken Glass Disposal Cartons", located just inside the chase doors at either end of the clean room corridor.
- Disposable particulate respirators and chemical gloves **must** be worn at all times while doing a "wet clean" on the III-V vacuum chamber due to the risk of

exposure to arsenic dust. All items, e.g., wipes, gloves, Sotch Brite™, etc. **must** be double bagged and labeled, "Hazardous Waste – Arsenic Dust" and placed in the bottom of the solvent storage cabinet located in the clean room corridor for disposal by ONF staff.

MSDS Material Safety Data Sheet

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

Mallinckrodt CHEMICALS | J.T.Baker

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

# HYDROFLUORIC ACID

## 1. Product Identification

**Synonyms:** Fluorohydric acid; fluoric acid; Hydrogen fluoride solution
**CAS No.:** 7664-39-3
**Molecular Weight:** 20.01
**Chemical Formula:** HF in Aqueous Solution.
**Product Codes:**
J.T. Baker: 5368, 5659, 5818, 5823, 5824, 5840, 5865, 5900, 6904, 9559, 9560, 9563, 9564, 9567, 9572, 9573, 9574
Mallinckrodt: 2640, 2648, V141, V580

## 2. Composition/Information on Ingredients

| Ingredient | CAS No | Percent | Hazardous |
|---|---|---|---|
| Hydrogen Fluoride | 7664-39-3 | 48 - 52% | Yes |
| Water | 7732-18-5 | 48 - 52% | No |

# 3. Hazards Identification

**Emergency Overview**
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**POISON! DANGER! CORROSIVE. EXTREMELY HAZARDOUS LIQUID AND VAPOR. CAUSES SEVERE BURNS WHICH MAY NOT BE IMMEDIATELY PAINFUL OR VISIBLE. MAY BE FATAL IF SWALLOWED OR INHALED. LIQUID AND VAPOR CAN BURN SKIN, EYES AND RESPIRATORY TRACT. CAUSES BONE DAMAGE. REACTION WITH CERTAIN METALS GENERATES FLAMMABLE AND POTENTIALLY EXPLOSIVE HYDROGEN GAS.**

**SAF-T-DATA(tm)** Ratings (Provided here for your convenience)
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Health Rating: 4 - Extreme (Poison)
Flammability Rating: 0 - None
Reactivity Rating: 2 - Moderate
Contact Rating: 4 - Extreme (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: White (Corrosive)
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**Potential Health Effects**
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Exposure to hydrofluoric acid can produce harmful health effects that may not be immediately apparent.

**Inhalation:**
Severely corrosive to the respiratory tract. May cause sore throat, coughing, labored breathing and lung congestion/inflammation.
**Ingestion:**
Corrosive. May cause sore throat, abdominal pain, diarrhea, vomiting, severe burns of the digestive tract, and kidney dysfunction.
**Skin Contact:**
Corrosive to the skin. Skin contact causes serious skin burns which may not be immediately apparent or painful. Symptoms may be delayed 8 hours or longer. The fluoride ion readily penetrates the skin causing destruction of deep tissue layers and even bone.
**Eye Contact:**
Corrosive to the eyes. Symptoms of redness, pain, blurred vision, and permanent eye damage may occur.
**Chronic Exposure:**

Intake of more than 6 mg of fluorine per day may result in fluorosis, bone and joint damage. Hypocalcemia and hypomagnesemia can occur from absorption of fluoride ion into blood stream.

**Aggravation of Pre-existing Conditions:**

Persons with pre-existing skin disorders, eye problems, or impaired kidney or respiratory function may be more susceptible to the effects of this substance.

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# 4. First Aid Measures

For any route of contact: Detailed First Aid procedure should be planned before beginning work with HF.

**Inhalation:**

Get medical help immediately. If patient is unconscious, give artificial respiration or use inhalator. Keep patient warm and resting, and send to hospital after first aid is complete.

**Ingestion:**

If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.

**Skin Contact:**

1) Remove the victim from the contaminated area and immediately place him under a safety shower or wash him with a water hose, whichever is available. 2) Remove all contaminated clothing. Handle all HF-contaminated material with gloves made of appropriate material, such as PVC or neoprene. 3) Keep washing with large amounts of water for a minimum of 15 minutes. 4) Have someone make arrangements for medical attention while you continue flushing the affected area with water. 5) If the following materials are available, limit the washing to five minutes and immerse the burned area in a solution of 0.2% iced aqueous Hyamine 1622 or 0.13% iced aqueous Zephiran Chloride. If immersion is not practical, towels should be soaked with one of the above solutions and used as compresses for the burn area. Ideally compresses should be changed every 2 minutes. Alternately, 2.5% calcium gluconate gel should be massaged into the affected area. 6) Seek medical attention as soon as possible for all burns regardless of how minor they may appear initially. Hyamine 1622 is a trade name for tetracaine benzethonium chloride, Merck Index Monograph 1078, a quaternary ammonium compound sold by Rohm & Haas, Philadelphia. Zephiran Chloride is a trade name for benzalkonium chloride, Merck Index Monograph 1059, also a quaternary ammonium compound, sold by Sanofi-Synthelabo Inc., New York, NY.

**Eye Contact:**

1) Irrigate eyes for at least 30 minutes with copious quantities of water, keeping the eyelids apart and away from eyeballs during irrigation. 2) Get competent medical attention immediately, preferably an eye specialist. 3) If a physician is not immediately available, apply one or two drops of ophthalmic anesthetic, (e.g., 0.5% Pontocaine Hydrochloride solution). 4) Do not use oily drops, ointment or HF skin burn treatments. Place ice pack on eyes until reaching emergency room.

**Note to Physician:**

General: For burns of moderate areas, (greater than 8 square inches), ingestion and

significant inhalation exposure, severe systemic effects may occur, and admission to a critical care unit should be considered. Monitor and correct for hypocalcemia, cardiac arrhythmias, hypomagnesemia and hyperkalemia. In some cases renal dialysis may be indicated.

Inhalation: Treat as chemical pneumonia. Monitor for hypocalcemia, 2.5% calcium gluconate in normal saline by nebulizer or by IPPB with 100% oxygen may decrease pulmonary damage. Bronchodilators may also be administered.

Skin: For deep skin burns or contact with concentrated HF (over 50%) solution, consider infiltration about the affected area with 5% calcium gluconate [equal parts of 10% calcium gluconate and sterile saline for injection]. Burns beneath the nail may require splitting the nail and application of calcium gluconate to the exposed nail bed. For certain burns, especially of the digits, use of intra-arterial calcium gluconate may be indicated.

Eyes: Irrigation may be facilitated by use of Morgan lens or similar ocular irrigator, using 1% aqueous calcium gluconate solution [50ml of calcium gluconate 10% in 500 ml normal saline].

AN ALTERNATIVE FIRST AID PROCEDURE: The effect of HF, i.e. onset of pain, particularly in dilute solutions, may not be felt for up to 24 hours. It is important, therefore, that persons using HF have immediate access to an effective antidote even when they are away from their work place in order that first aid treatment can be commenced immediately.
We recommend that any person in contact with HF should carry, or have access to a tube of HF Antidote Gel at all times; ideally with one tube at the work place, one on the person and one at home.
It is imperative that any person who has been contaminated by HF should seek medical advice when the treatment by HF Antidote Gel has been applied.
REFERENCES: 1. Browno, T.D. Treatment of Hydrofluoric Acid Burns 2. Sprout, W.L. et al Treatment of Severe Hydrofluoric Acid Exposures (Journal of American Occupational Medicine 25:12, 1993) 3. Bracken, W.M. et al Comparative Effectiveness of Topical Treatments for Hydrofluoric Acid Burns, University of Kansas (Journal of Occupational Medicine 27:10:1985) 4. Burke, W.J. , et al Systemic Fluoride Poisoning Resulting from A Fluoride Skin Burn (Journal of Occupational Medicine (5,39:1973)

HF ANTIDOTE GEL:
Distributed by Pharmascience Inc.
8400 Darnley Rd. Montreal, Canada. H4T 1M4
Phone: ( 514 ) 340 - 1114
Fax: ( 514 ) 342 - 7764
U.S. (Buffalo, NY) distributor: 1-800-207-4477

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# 5. Fire Fighting Measures

**Fire:**
Not considered to be a fire hazard. Fire may produce poisonous or irritating gases.
**Explosion:**
Violent exothermic reaction occurs with water. Sufficient heat may be produced to ignite combustible materials. Reacts with metals forming flammable Hydrogen gas.
**Fire Extinguishing Media:**
Keep upwind of fire. Use water or carbon dioxide on fires in which Hydrofluoric Acid is involved. Halon or foam may also be used. In case of fire, the sealed containers can be kept cool by spraying with water.
**Special Information:**
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Avoid getting water in tanks or drums; water can cause generation of heat and spattering. In contact with air, the acid gives off corrosive fumes which are heavier than air.

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# 6. Accidental Release Measures

Notify safety personnel, provide adequate ventilation, and remove ignition sources since hydrogen may be generated by reactions with metals. Wear appropriate personal protective equipment as specified in Section 8. Do not flush to sewers or waterways. Spills: Evacuate the danger area. Apply magnesium sulfate (dry) to the spill area. Follow up with inert absorbent and add soda ash or magnesium oxide and slaked lime. Collect in appropriate plastic containers and save for disposal. Wash spill site with soda ash solution. NOTE: Porous materials (concrete, wood, plastic, etc.) will absorb HF and become a hazard for an indefinite time. Such spills should be cleaned and neutralized immediately. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker NEUTRASORB® acid neutralizers are recommended for spills of this product.

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# 7. Handling and Storage

Keep in tightly closed polyethylene containers. Store in a cool, dry place with adequate ventilation separated from other chemicals. Protect from physical damage. Storage facilities should be constructed for containment and neutralization of spills. Handling and storage of HF requires special materials and technology for containers, pipes, valves, etc., which is available from suppliers. Containers of this material may be hazardous when

empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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# 8. Exposure Controls/Personal Protection

**Airborne Exposure Limits:**
Hydrogen fluoride:
-OSHA Permissible Exposure Limit (PEL):
3 ppm (TWA)
ACGIH Threshold Limit Value (TLV):
3 ppm Ceiling as F
**Ventilation System:**
A system of local and/or general exhaust is recommended to keep employee exposures as low as possible. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
**Personal Respirators (NIOSH Approved):**
If the exposure limit is exceeded, a full facepiece respirator with an acid gas cartridge may be worn up to 50 times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air purifying respirators do not protect workers in oxygen-deficient atmospheres. Since the IDLH is low (30 ppm), the above cartridge system is not specifically approved for HF. (3M Respirator Selection Guide)
**Skin Protection:**
Wear protective clothing, including boots or safety shoes with polyvinyl chloride (PVC) or neoprene. Use chemical goggles and/or a full face shield. Wear coveralls with long sleeves, gauntlets and gloves of PVC or neoprene. A high degree of protection is obtained with an air-inflated suit with mask and safety belt. Use protection suitable for conditions.
**Eye Protection:**
Use chemical safety goggles and/or full face shield where splashing is possible. Maintain eye wash fountain and quick drench facilities in work area.

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# 9. Physical and Chemical Properties

**Appearance:**
Colorless, fuming liquid.
**Odor:**
Acrid odor. Do not breathe fumes.
**Solubility:**
Infinitely soluble.

**Specific Gravity:**
1.15 -1.18
**pH:**
1.0 (0.1M solution)
**% Volatiles by volume @ 21C (70F):**
100 (as water and acid)
**Boiling Point:**
108C (226F)
**Melting Point:**
< -36C (< -33F)
**Vapor Density (Air=1):**
1.97
**Vapor Pressure (mm Hg):**
25 @ 20C (68F)
**Evaporation Rate (BuAc=1):**
No information found.

---

# 10. Stability and Reactivity

**Stability:**
Stable at room temperature (68F) when stored and used under proper conditions.
**Hazardous Decomposition Products:**
On contact with metals, liberates hydrogen gas. On heating to decomposition, could yield toxic fumes of fluorides. Attacks glass and other silicon containing compounds. Reacts with silica to produce silicon tetrafluoride, a hazardous colorless gas.
**Hazardous Polymerization:**
Will not occur.
**Incompatibilities:**
Hydrofluoric acid is incompatible with arsenic trioxide, phosphorus pentoxide, ammonia, calcium oxide, sodium hydroxide, sulfuric acid, vinyl acetate, ethylenediamine, acetic anhydride, alkalis, organic materials, most common metals, rubber, leather, water, strong bases, carbonates, sulfides, cyanides, oxides of silicon, especially glass, concrete, silica, fluorine. Will also react with steam or water to produce toxic fumes.
**Conditions to Avoid:**
Moisture and incompatibles.

---

# 11. Toxicological Information

Hydrofluoric acid: Inhalation rat LC50: 1276 ppm/1H; Investigated as a mutagen, reproductive effector.

```
  --------\Cancer Lists\----------------------------------------------
-------
                                          ---NTP Carcinogen---
```

```
  Ingredient                              Known    Anticipated    IARC
Category
  ----------------------------------   -----    -----------    ------
-------
  Hydrogen Fluoride (7664-39-3)          No          No
None
  Water (7732-18-5)                      No          No
None
```

---

# 12. Ecological Information

**Environmental Fate:**
If the pH is > 6.5, soil can bind fluorides tightly. High calcium content will immobilize fluorides, which can be damaging to plants when present in acid soils.
**Environmental Toxicity:**
This material is expected to be slightly toxic to aquatic life. 60 ppm/*/Fish/Lethal/Fresh Water *=time period not specified. > 300ppm/48hr./Shrimp/LC50/Aerated Saltwater

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# 13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

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# 14. Transport Information

**Domestic (Land, D.O.T.)**
---
**Proper Shipping Name:** RQ, HYDROFLUORIC ACID (WITH NOT MORE THAN 60% STRENGTH)
**Hazard Class:** 8, 6.1
**UN/NA:** UN1790
Packing Group: II
**Information reported for product/size:** 500LB

**International (Water, I.M.O.)**
---
**Proper Shipping Name:** HYDROFLUORIC ACID (WITH NOT MORE THAN 60% STRENGTH)
**Hazard Class:** 8, 6.1

**UN/NA:** UN1790
Packing Group: II
**Information reported for product/size:** 500LB

---

# 15. Regulatory Information

--------\Chemical Inventory Status - Part 1\--------

| Ingredient | TSCA | EC | Japan | Australia |
|---|---|---|---|---|
| Hydrogen Fluoride (7664-39-3) | Yes | Yes | Yes | Yes |
| Water (7732-18-5) | Yes | Yes | Yes | Yes |

--------\Chemical Inventory Status - Part 2\--------

| | | --Canada-- | | |
|---|---|---|---|---|
| Ingredient | Korea | DSL | NDSL | Phil. |
| Hydrogen Fluoride (7664-39-3) | Yes | Yes | No | Yes |
| Water (7732-18-5) | Yes | Yes | No | Yes |

--------\Federal, State & International Regulations - Part 1\--------

| | -SARA 302- | | ------SARA 313------ | |
|---|---|---|---|---|
| Ingredient | RQ | TPQ | List | Chemical Catg. |
| Hydrogen Fluoride (7664-39-3) | 100 | 100 | Yes | No |
| Water (7732-18-5) | No | No | No | No |

--------\Federal, State & International Regulations - Part 2\--------

| | | -RCRA- | - TSCA- |
|---|---|---|---|
| Ingredient | CERCLA | 261.33 | 8(d) |
| Hydrogen Fluoride (7664-39-3) | 100 | U134 | No |
| Water (7732-18-5) | No | No | No |

```
Chemical Weapons Convention:  Yes    TSCA 12(b):  No     CDTA:  No
SARA 311/312:  Acute: Yes      Chronic: Yes  Fire: No  Pressure: No
Reactivity: Yes         (Mixture / Liquid)
```

**Australian Hazchem Code:** 2R
**Poison Schedule:** S7
**WHMIS:**
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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# 16. Other Information

**NFPA Ratings:** Health: **4** Flammability: **0** Reactivity: **1**
**Label Hazard Warning:**
POISON! DANGER! CORROSIVE. EXTREMELY HAZARDOUS LIQUID AND VAPOR. CAUSES SEVERE BURNS WHICH MAY NOT BE IMMEDIATELY PAINFUL OR VISIBLE. MAY BE FATAL IF SWALLOWED OR INHALED. LIQUID AND VAPOR CAN BURN SKIN, EYES AND RESPIRATORY TRACT. CAUSES BONE DAMAGE. REACTION WITH CERTAIN METALS GENERATES FLAMMABLE AND POTENTIALLY EXPLOSIVE HYDROGEN GAS.
**Label Precautions:**
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor.
Cool before opening.
Use only with adequate ventilation.
Wash thoroughly after handling.
Store in a tightly closed container.
**Label First Aid:**
IN ALL CASES, CALL PHYSICIAN IMMEDIATELY. First Aid procedures should be pre-planned for HF emergencies. A supply of 50:50 water/magnesium sulfate paste or 2 1/2% Calcium Gluconate paste should be available where first aid medications are administered. If ingested, DO NOT INDUCE VOMITING. If patient is conscious, give large quantities of milk or water and send to hospital. If inhaled and patient is unconscious, give artificial respiration or use inhalator and send to hospital. In case of eye contact, wash open eyes with large but gentle stream of water for 15 minutes. Place ice pack on eyes until reaching emergency room. In case of skin contact, remove contaminated clothing and wash burn area with plenty of water to remove acid. Cover burn area with a poultice of 50:50 water/magnesium sulfate paste or 2 1/2% calcium gluconate paste. Leave in place until medical help arrives or patient is transferred to hospital.
**Product Use:**
Laboratory Reagent.
**Revision Information:**
MSDS Section(s) changed since last revision of document include: 3.

**Disclaimer:**

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**Prepared by:** Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

## Appendix B – Tool Operation and Maintenance

**Tool "Guru"**
Person(s) designated as responsible for training and maintenance on a particular system. Refer to the http://opticscenter.uncc.edu/equipment.htm for the equipment list and tool "guru".
*Function*: Knows the equipment best and will either fix the system on major issues involving intimate knowledge of the tool and its functioning or have the necessary contact information to take the appropriate steps. They will also provide appropriate training for those that need to use the system. Their contact information will be posted on the tool and/or on the online system.

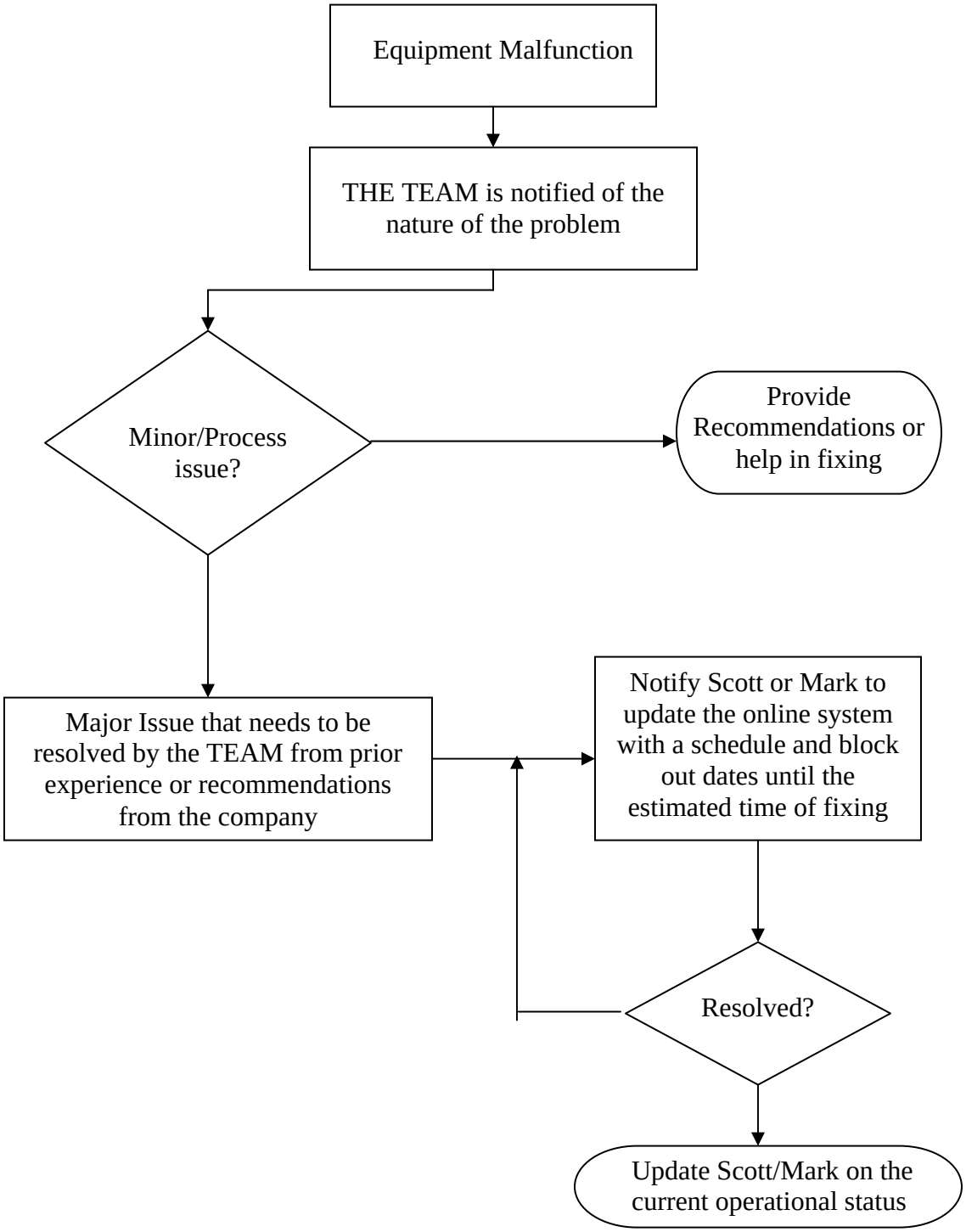
**Super User**
Person(s) picked from among the graduate students by the tool "guru".
*Function*: The purpose of the super user is to help with routine maintenance procedures, maintaining log sheets and help the 'gurus' with training new users. It is also to help other users with minor process issues or development that may be essential from time to time. The super user can also fill in for the tool "guru" in his absence.

**Training**
Training will be provided by the "guru" for each tool at the outset. This will ensure that there is a single source of information regarding procedures that can then be enforced by the tool "guru"/ super user team. At a later stage the "guru" may designate the super user to training as matter of convenience. The team for the equipment will also have the administrator password and decide on access levels of the each user on the system. The super user can play an active role in this process if he so chooses by evaluating the competence of the user concerned in order to determine if the person may be allowed a higher level of access. In the longer term, training may also be provided by other certified users of the tool. However, certification for unsupervised use can be obtained only from the tool "guru". This may also be necessary since the tool "guru" will only provide information of the generic functionality of tool and operating procedures. Process or project specific recommendations may be obtained from other users or the super user.

**Logging and Reporting**
The user log sheets will have to be filled in by every user to aid in troubleshooting, tracking materials issues and usage statistics. Minor issues in process stability and tool operation will be made note of in the log sheet. Major problems that impede normal operation of the tool will have to be reported immediately and tool will not be operational until either one of the team responsible for the equipment has taken a look at it. The Team will need to be notified of any new materials or drastically new processes that are introduced in the system so that their effect on the tool and standard operation can be studied appropriately. This may involve either contacting the manufacturer for their recommendations. All processes with detailed information of parameters will be logged on every tool. A log sheet template has been provided as an example.

**Materials**
Consumables for the tools will be ordered by the ‘guru’ though the super user and certified users will assist in this process to avoid down times due lacking inventory.

**Tool Breakdown Procedures**
The team responsible for the tool will be notified of all issues pertaining to it by the person using it when it arises. Once this is done they will determine the nature of the problem and provide the user with recommendations or help in fixing it in the case of minor issues. Major problems will require the team to make a determination of the steps necessary to resolve the issue. This may involve troubleshooting based on experience or contacting the company for ideas or parts. The team will notify Mark or Scott with a schedule for resolving the issue and let the users know by posted signs or via email. Once the issues have been resolved, the tool will brought back online and the system updated with the current status of the tool.


Equipment Malfunction
THE TEAM is notified of the nature of the problem
Minor/Process issue?
Provide Recommendations or help in fixing
Major Issue that needs to be resolved by the TEAM from prior experience or recommendations from the company
Notify Scott or Mark to update the online system with a schedule and block out dates until the estimated time of fixing
Resolved?
Update Scott/Mark on the current operational status