SAFETY AND HEALTH PROGRAM

Including the Chemical Hygiene Plan

Wisconsin Center for Applied Microelectronics

University of Wisconsin — College of Engineering

1550 Engineering Drive

Madison, Wisconsin 53706

Safety and Health Program

For

The Wisconsin Center for Applied Microelectronics

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Safety and Health Committee

Jerry Hunter, Director of Shared Facilities
jhunter5@wisc.edu
263-1073

Dan Christensen, Lab Manager
dan@engr.wisc.edu
262-6877

Quinn Leonard, Technical Staff
qleonard@wisc.edu
890-3030

Hal Gilles, Technical Staff
hgilles@wisc.edu
890-4573

Kurt Kupcho, Technical Staff & Chemical Hygiene Officer
kakupcho@wisc.edu
262-2982

Edward Gonzales, Technical Staff
efgonzales@wisc.edu
265-3148

Lab Facility Website

http://www.engr.wisc.edu/centers/wcam

TABLE OF CONTENTS

V. Rules and Policies

VI. Training

VII. General Laboratory Safety and Health Procedures

VIII. Hazard Awareness and Response

IX. Medical Consultation and Examination

I. Introduction

1.1 Scope of Program

This Safety and Health Program is extension of a Chemical Hygiene Plan (CHP). The program is designed to be a management tool to ensure the safety and health of employees and users of the Wisconsin Center for Applied Microelectronics laboratory facilities. The program was prepared in a good faith effort to comply with regulations set by the U.S. Occupational Safety and Health Administration (OSHA), the State of Wisconsin, and the University of Wisconsin. See ***Section X*** for a list of the reference resources which were used to compile the program components.

1.2 Basic Program Components

- Involvement of management, employees and users of the lab in program development of safety and health procedures;
- Analysis of safety and hazardous materials in work areas;
- Prevention and controls measures for safety and hazardous exposures;
- Training for the employees and users of the lab.

This document consists of detailed descriptions of program components, including procedures for their implementation. The chemical hygiene officer will maintain specific documents resulting from program implementation, such as equipment testing or training test results, in separate records.

II. Commitment to Program Development

2.1 Statement of Purpose

2.1.1 Definitions

"Management" will be comprised of the lab manager and/or any person(s) representing the College of Engineering Administration.

"Chemical Hygiene Officer" will be an employee designated by the lab manager. The person will be qualified by training or experience to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan.

"Employee" means any person employed by the University of Wisconsin and assigned by the College of Engineering to the staff of the Wisconsin Center for Applied Microelectronics.

"Safety and Health Committee" will be comprised of management, the chemical hygiene officer and all employees. The duties of the committee will be to review and set policies and procedures relating to lab safety and the health of persons working in the lab.

"User" means any person entering the facility for the purposes of research or course work. A user is not an employee or a trespasser.

2.1.2 Responsibilities

Management will:

- Inspect and maintain the operation of the lab facilities and equipment within the lab.
- Provide the necessary resources of staff and equipment to ensure that all persons working in the lab facilities are protected from injury and illness hazards.
- Provide necessary information relevant to program development.
- Assign an employee the duties of chemical hygiene officer.
- Participate as a member of the Safety and Health Committee.

Chemical Hygiene Officer will:

- Maintain the Safety and Health Program and the Chemical Hygiene Plan.
- Maintain records of documents relating to procedures set within the program.
- Provide written procedures and training for operation of equipment.
- Provide written procedures and training of all chemical processes performed in the lab.
- Schedule routine training for employees and users.
- Provide a prompt response to recommendations submitted by employees and users.
- Participate as a member of the Safety and Health Committee.
- Maintain emergency response supplies.

Employees will:

- Obtain medical approval for use of self-containing breathing apparatus (SCBA).
- Test for respirator fit. The fit test will be provided by University Health Services (UHS).
- Training and practice use of SCBA equipment if medical approval and respirator fit test is on record with the chemical hygiene officer.
- Participate in training for lab safety, fire extinguishers, and chemical use.
- Participate as a member of the Safety and Health Committee.
- Train users on safe use of chemicals and equipment in WCAM.

Users will:

- Participate in training for lab safety, fire extinguishers, and chemical use.
- Adhere to proper lab rules, policies and lab safety procedures.
- Adhere to proper equipment operating procedures.
- Report any malfunction or misuse of equipment or lab facilities.
- Recommend changes to improve lab procedures and environment.
- Advocate proper safety procedures to colleagues working in the lab.

2.2 Safety and Health Program Review

2.2.1 Review Procedures

The Safety and Health Program is a dynamic program that will be adjusted to the dynamic needs of the lab based on the responses of employees and users. The program will be formally reviewed yearly by the Chemical Hygiene Officer. All employees and users are encouraged to suggest additions or revisions to the program throughout the year. Members of the Safety and Health Committee will be consulted for specific procedures with regard to maintenance and operation of laboratory equipment.

2.2.2 Program Review

Date	***Actions Taken***
June 2017	• Updated staff and contacts • Updated to include new chemical labeling and Safety Data Sheet under the new GHS guidelines • Updated to reflect new cleanroom operations software FOM
September 2016	• Updated staff and contacts • Change of Chemical Hygiene Officer • Update whole document based on changes since May 2011
May, 2011	• Revised rules and policies regarding chemical safety and micro/nano fabrication
August, 2010	• Updated staff contacts • Revised lab policies • Deleted ion implanter gas list • Section VIII added • Renumbered sections
December, 2006	• Add AED responsibility for employees to Section 2.1.2 • Add MSDS binder to fire control room, Section 3.3.2 • Expand compressed gas emergency action, Section 4.1.1.4 • Add wet bench exhaust inspection to Section 4.2.1 • Add description of user annual renewal, Section 5.2.2 • Add Hazardous Gas Alarm, Section 7.11 • Add Evacuation Procedures, Section 7.13 • Edit table of contents and index
September, 2003	• Introduction of S&H Program components • Complete revision and reorganization of CHP • Insert new section 4.1.1 Compressed Gas Handling Protocol • Separate record keeping from CHP • Removal of equipment operating procedures from CHP
October, 2001	• Section I. Update references to WCAM Safety Handbook. • Section IV. Revised statement on yearly review of lab procedures. • Section VI. Added statement on emergency response. • Section VIII. Revised sections of criteria. • Appendix B. Revised Chemical Hygiene Protocol. • Appendix C. Inserted new lab tour and user information forms. • Appendix G. Electrical safety to be revised. • Appendix I. Compressed gas cylinder change protocol to be revised. • Appendix J. Silane gas cylinder change protocol to be revised. • Appendix M. Additions to the equipment procedures.
January, 2001	• Section II. Expanded criteria to include transport of hazardous chemicals. • Section III. Added statement of lab tour.

	• Section IV. Added statement on yearly review of lab procedures. • Section VI. Added statement on emergency response. • Section VIII. Expanded all sections of criteria. • Appendix C. Added new lab tour form and safety handbook. • Appendix G. Electrical safety to be revised. • Appendix I. Compressed gas cylinder change protocol to be revised. • Appendix J. Silane gas cylinder change protocol to be revised.
October, 1999	• Section I. Changed Chemical Safety Protocol to Appendix B. Included Safety Tour Checklist and WCAM Safety Handbook, Appendix C. • Section III. Included exhaust inspection check off schedule, Appendix C • Section IV. Changed training schedule to Appendix E. Expand training statement. • Appendix F. Exhaust Inspection Schedule added. • Appendix I. Revised compressed gas cylinder change protocol. • Appendix J. Revised silane gas cylinder change protocol. Appendix K. Revised vacuum pump oil change protocol.

Chemical Hygiene Plan
III. Work-Site Analysis and Hazard Identification

3.1 Hazardous Chemical and Gas Inventory

Understanding the nature of the hazardous and toxic materials in the lab is important. To provide a safe and efficient environment, all employees and users should be aware of safe lab procedures and the hazards associated with the materials they will be using in the lab.

Documents and publications dealing with hazardous materials and procedures are contained in the Right-To-Know area. The area is located inside the Cleanroom gowning area, Engineering Centers Building Room 3039. The following publications are located in the Right-To-Know area:

- The Occupational Safety and Health Administration (OSHA) Standards
- The Emergency Response Guidebook
- The Chemical Safety and Disposal Guide by the UW Safety Department
- The Safety and Health Program for the Wisconsin Center for Applied Microelectronics
- Library of MSDS and SDS for chemicals used in the lab

The following lists contain the most commonly used chemicals and gases in the WCAM lab. This is not a comprehensive list but only to provide you with basic knowledge of the categories, safe handling and exposure effects. The Emergency Response Guide provides a more detailed response. A complete inventory of materials and disclosure of hazards and safety procedures are

available through the Safety Data Sheets located in the Right to Know Area, ECB Room 3039. A supplemental, incomplete list is also available in the fire control room for the building (ECB Room M1069). Outside of the WCAM's chemical storage room, ECB 3042, there is also a complete list of chemicals stored, on-average inventory, and SDS for each chemical.

3.1.1 Acids and Bases

Chemical	Emergency Response Guide No.	Category
Acetic acid	132 – flammable liquid, corrosive	acid
Ammonium fluoride	154 – toxic and/or corrosive, non-combustible	base
Ammonium hydroxide	154 – toxic and/or corrosive, non-combustible	base
BOE (buffered oxide etchant)	157 – toxic and/or corrosive, non-combustible/water-sensitive	acid
CR-14 chromium etchant	132/140 – flammable liquid, corrosive, oxidizer	acid
Defreckling aluminum etchant	154 – toxic and/or corrosive, non-combustible	acid
Hydrochloric acid	157 – toxic and/or corrosive, non-combustible/water-sensitive	acid
Hydrogen peroxide	140 - Oxidizer	acid
Hydrofluoric acid	157 – toxic and/or corrosive, non-combustible/water-sensitive	acid
MF 321 Developer	153 – toxic and/or corrosive, combustible	base
Nitric acid	157 – toxic and/or corrosive, non-combustible/water sensitive	acid
Phosphoric acid	154 – toxic and/or corrosive, non-combustible	acid
Potassium hydroxide	154 – toxic and/or corrosive, non-combustible	base
Sulfuric acid	137 – water reactive, corrosive	acid

Safe Handling of Corrosives. Acids and bases react violently if mixed with each other. Keep chemicals separate. Water reacts violently with corrosives. Remember the rule: Always Add Acid to water (AAA). Corrosives can cause severe skin and eye damage. Do not wear contact lenses. Wear personal protective equipment at all times. **Always use corrosives on the exhausted wet bench to prevent exposure.**

Short-Term Exposure Effects. Exposure to strong acid or basic vapors or mist may cause eye, nose and throat burns or irritation. Direct contact with strong acids or bases may result in severe skin damage and could permanently damage eyesight.

Long-Term Exposure Effects. Repeated or prolonged exposure to dilute solutions of acid or bases may cause skin irritation. Repeated or prolonged exposure to mists or vapors may cause erosion of the teeth, chronic irritation of the eyes, or chronic inflammation of the nose, throat, and respiratory system.

Emergency Treatment. Get medical attention immediately in all situations.
Eyes: Wash eyes immediately with large amounts of water for 15 minutes.
Skin: Flush contaminated skin with large amounts of water. Remove any contaminated clothing. Hydrofluoric acid is extremely hazardous. After flushing with water, apply calcium gluconate gel.
Breathing: Remove exposed person to fresh air. CPR may be necessary.
Swallowing: Drink large quantities of water to dilute chemical. Do not attempt to induce vomiting.

3.1.2 Oxidizers

Chemical	Emergency Response Guide No.
CR-14 chromium etchant	132/140 – flammable liquid, corrosive, oxidizer
Hydrogen Peroxide	140 – oxidizer
Nitric acid	157 – toxic and/or corrosive, non-combustible/water sensitive, oxidizer
Xenon Difluoride	140/157 – Oxidizer, toxic and/or corrosive, non-combustable/water sensitive

Safe Handling of Oxidizers: Oxidizers should be kept separate from combustibles, ignition sources, heat, sunlight, flammables, acids, bases, and organic materials.

3.1.3 Solvents

Chemical	Emergency Response Guide No.
Acetone	127 – flammable liquid
Ethanol	127 – flammable liquid
Edge Bead Remover PG	132 – flammable liquid, corrosive
Hexamethyldisilazane (HMDS)	132 – flammable liquid, corrosive
Isopropyl alcohol	129 – flammable liquid, noxious
Methanol	131 – flammable liquid, toxic
Photoresists	153 – toxic and/or corrosive (combustible)
Remover 1165	132 – flammable liquid, corrosive
SU8 photoresist	153 – toxic and/or corrosive (combustible)
SU8 developer	153 – toxic and/or corrosive (combustible)

Safe Handling of Flammables. Solvents can be combustible and/or flammable. Keep away from a source of ignition and use minimum quantities. Avoid skin contact and breathing the vapors. **Always use solvents on a stainless steel exhausted wet bench to prevent exposure.** When heating solvents on a hotplate, a user must be present; in front of the hotplate watching it 100% of the time a beaker is on the hotplate.

Short-Term Exposure Effects. Exposure to very high concentrations may cause severe irritation, drowsiness, unconsciousness and death. High concentrations may cause headache, weakness, drowsiness, dizziness, nausea and irritation of the eyes and nose. Moderate concentrations may cause some nausea and light irritation.

Long-Term Exposure Effects. Effects are comparable to short-term effects, plus possible specific internal organ damage.

Emergency Treatment.
Eyes: Wash eyes immediately with large amounts of water for 15 minutes. The person may need further medical attention.
Skin: Wash with soap and water. Remove any contaminated clothing. Skin irritation may require further medical attention.
Breathing: Remove exposed person to fresh air. CPR may be necessary.
Swallowing: Get medical attention immediately.

3.1.4 Compressed Gases

Gas	Emergency Response Guide No.
Ammonia	125 – corrosive
Argon	121 – inert
Boron trichloride	125 –corrosive
Tetrafluoromethane	126 – compressed or liquified
Trifluoromethane	126 – compressed or liquified
Octafluorocyclobutane	126 – compressed or liquified
Chlorine	124 – Toxic and/or corrosive, oxidizing
Dichlorosilane	119 – toxic, flammable
Helium	121 – inert
Hydrogen	115 – flammable
Nitrogen	121 – inert
Methane	115 - flammable
Nitrous oxide	122 – oxidizing
Oxygen	122 – oxidizing
Phosphine	119 – toxic, flammable
Silane	116 – flammable (unstable)
Sulfur hexafluoride	126 – compressed or liquified

Safe Handling of Gases. All cylinders are to be securely attached to a wall or sturdy fixture. All WCAM gas cylinders in use, except for forming gas and helium, are in exhausted gas cabinets with gas cabinet controllers able to shut the valve on the main gas cylinder if a hazardous condition is detected. No cylinder should be transported without a cylinder cart and its cap on. Some gases, such as silane, can produce violent explosions and should be handled with great respect. Toxic gas leaks can quickly reach hazardous levels. Only staff with proper training will handle or change cylinders of all gases.

Short-Term Exposure Effects. Breathing high concentrations of gases can cause dizziness, unconsciousness or death. Exposure to toxic gases may also cause severe eye and respiratory irritations. Sudden release of gas can freeze skin.

Long-Term Exposure Effects. Similar to short term.

Emergency Treatment. Get medical attention immediately in all situations.
Eyes: Get medical treatment.
Skin: Get medical treatment.
Breathing: Remove exposed person to fresh air. CPR may be necessary.

3.2 Container Labels

3.2.1 WCAM Supplied Chemicals

Each chemical will be stored in its original container or in a labeled secondary container. In addition to the manufacturer's label, each chemical bottle within the lab will have several possible labels (see the following examples). WCAM uses all of the explained labeling systems.

Emergency Response Guide (ERG) Number Label

The emergency response guide number refers to a book page in the Emergency Response Guidebook that identifies the basic hazards, public safety issues, and appropriate fire, spill or first aid responses for a particular chemical.

Hazardous Materials Identification System (HMIS) Labels

HMIS label identifies the hazard categories for the end user as follows:

- **H** for health hazard;
- **F** for flammability;
- **R** for reactivity; and
- **PE** for personal protection.

The rating codes for each category indicate hazard severity:

- **4,** severe hazard;
- **3**, serious;
- **2**, moderate;
- **1**, slight; and
- **0** for minimal hazard.

The most commonly used **PE** code will be **D** for safety goggles, face shield, gloves and synthetic apron. Other codes that might be seen are:

- **A** – safety goggles (always to be worn in the lab)
- **B** – safety goggles, chemical gloves
- **C** – safety goggles, chemical gloves, synthetic apron

National Fire Protection Agency (NFPA) Diamond Labels

NFPA label identifies the hazard categories for transportation and fire fighters as follows:

- **Blue** for health hazard;
- **Red** for flammability;
- **Yellow** for Instability; and
- **White** for specific hazard

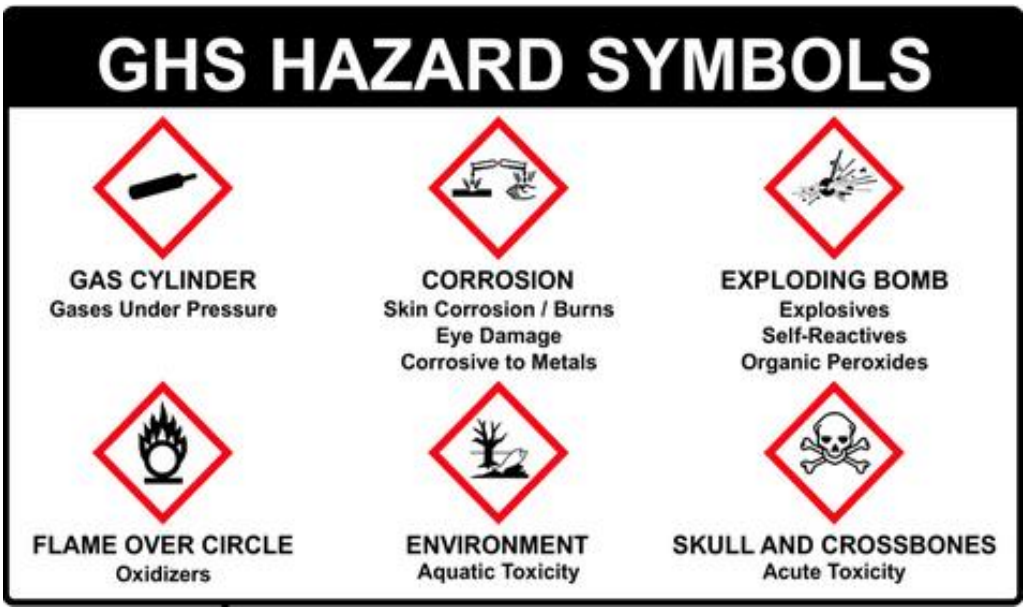
The NFPA label uses a severity range of 0-4 as well but mean slightly different things than an HMIS label, see example label to the right for numbering system.

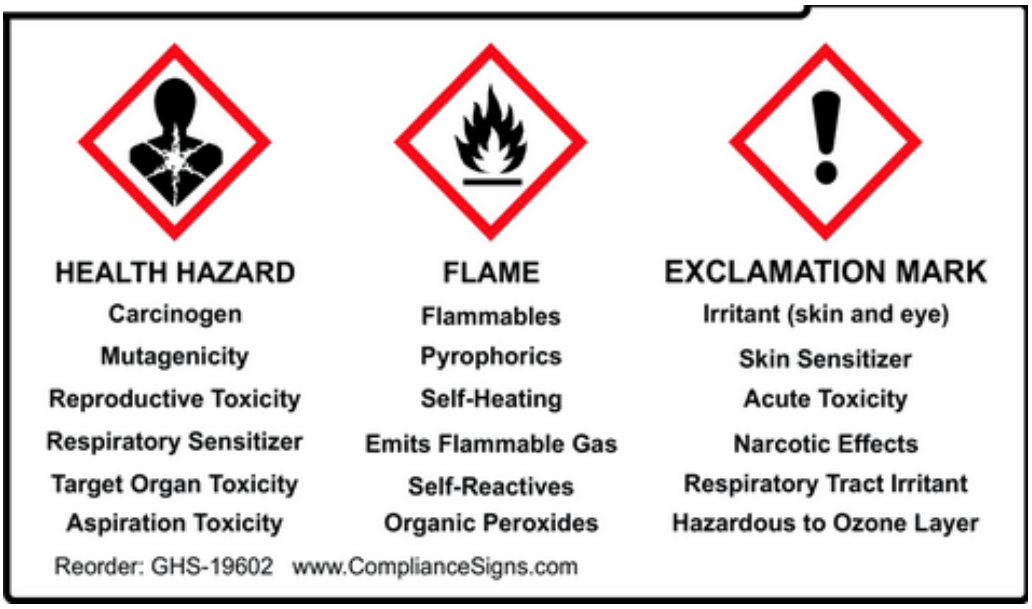
The white part of the NFPA diamond uses a code to explain a specific hazard for that material, see example to the right for code system.

Global Harmonized System (GHS) Labels

The newest chemical labeling system put in place 2015-2016 and meant to keep chemical labeling consistent across countries and companies. This labeling system uses pictograms, signal words, and hazard and precautionary statements to communicate hazards to the user on the chemical bottle.

GHS pictograms:





GHS signal words:

"Danger" or "Warning" will be used to emphasize hazards and indicate the relative level of severity of the hazard, assigned to a GHS hazard class and category. Some lower level hazard categories do not use signal words. Only one signal word corresponding to the class of the most severe hazard should be used on a label.

GHS hazard statements:

Standard phrases assigned to a hazard class and category that describe the nature of the hazard. An appropriate statement for each GHS hazard should be included on the label for products possessing more than one hazard. 200 series statements are for physical hazards, 300 series statements are for health hazards, and 400 series statements are for environmental hazards.

- H200: Unstable explosive
- H201: Explosive; mass explosion hazard
- H202: Explosive; severe projection hazard
- H203: Explosive; fire, blast or projection hazard
- H204: Fire or projection hazard
- H205: May mass explode in fire
- H220: Extremely flammable gas
- H221: Flammable gas
- H222: Extremely flammable aerosol
- H223: Flammable aerosol
- H224: Extremely flammable liquid and vapour
- H225: Highly flammable liquid and vapour
- H226: Flammable liquid and vapour
- H227: Combustible liquid

- H228: Flammable solid
- H229: Pressurized container: may burst if heated
- H230: May react explosively even in the absence of air
- H231: May react explosively even in the absence of air at elevated pressure and/or temperature
- H240: Heating may cause an explosion
- H241: Heating may cause a fire or explosion
- H242: Heating may cause a fire
- H250: Catches fire spontaneously if exposed to air
- H251: Self-heating; may catch fire
- H252: Self-heating in large quantities; may catch fire
- H260: In contact with water releases flammable gases which may ignite spontaneously
- H261: In contact with water releases flammable gas
- H270: May cause or intensify fire; oxidizer
- H271: May cause fire or explosion; strong oxidizer
- H272: May intensify fire; oxidizer
- H280: Contains gas under pressure; may explode if heated
- H281: Contains refrigerated gas; may cause cryogenic burns or injury
- H290: May be corrosive to metals
- H300: Fatal if swallowed
- H301: Toxic if swallowed
- H302: Harmful if swallowed
- H303: May be harmful if swallowed
- H304: May be fatal if swallowed and enters airways
- H305: May be harmful if swallowed and enters airways
- H310: Fatal in contact with skin
- H311: Toxic in contact with skin
- H312: Harmful in contact with skin
- H313: May be harmful in contact with skin
- H314: Causes severe skin burns and eye damage
- H315: Causes skin irritation
- H316: Causes mild skin irritation
- H317: May cause an allergic skin reaction
- H318: Causes serious eye damage
- H319: Causes serious eye irritation
- H320: Causes eye irritation
- H330: Fatal if inhaled
- H331: Toxic if inhaled
- H332: Harmful if inhaled
- H333: May be harmful if inhaled
- H334: May cause allergy or asthma symptoms or breathing difficulties if inhaled
- H335: May cause respiratory irritation
- H336: May cause drowsiness or dizziness
- H340: May cause genetic defects
- H341: Suspected of causing genetic defects
- H350: May cause cancer

- H351: Suspected of causing cancer
- H360: May damage fertility or the unborn child
- H361: Suspected of damaging fertility or the unborn child
- H361d: Suspected of damaging the unborn child
- H361f: Suspected of damaging fertility
- H362: May cause harm to breast-fed children
- H370: Causes damage to organs
- H371: May cause damage to organs
- H372: Causes damage to organs through prolonged or repeated exposure
- H373: May cause damage to organs through prolonged or repeated exposure
- H300+H310: Fatal if swallowed or in contact with skin
- H300+H330: Fatal if swallowed or if inhaled
- H310+H330: Fatal in contact with skin or if inhaled
- H300+H310+H330: Fatal if swallowed, in contact with skin or if inhaled
- H301+H311: Toxic if swallowed or in contact with skin
- H301+H331: Toxic if swallowed or if inhaled
- H311+H331: Toxic in contact with skin or if inhaled
- H301+H311+H331: Toxic if swallowed, in contact with skin or if inhaled
- H302+H312: Harmful if swallowed or in contact with skin
- H302+H332: Harmful if swallowed or if inhaled
- H312+H332: Harmful in contact with skin or if inhaled
- H302+H312+H332: Harmful if swallowed, in contact with skin or if inhaled
- H400: Very toxic to aquatic life
- H401: Toxic to aquatic life
- H402: Harmful to aquatic life
- H410: Very toxic to aquatic life with long-lasting effects
- H411: Toxic to aquatic life with long-lasting effects
- H412: Harmful to aquatic life with long-lasting effects
- H413: May cause long-lasting harmful effects to aquatic life
- H420: Harms public health and the environment by destroying ozone in the upper atmosphere

GHS precautionary statements:

GHS precautionary statement means a standard phrase that describes measures to minimize or prevent adverse effects of a chemical assigned to a hazard class and category. Each precautionary statement is designated a code, starting with the letter P and followed by 3 digits.

P1xx: general precautionary statement;
P2xx: prevention precautionary statement;
P3xx: response precautionary statement;
P4xx: storage precautionary statement;
P5xx: disposal precautionary statement;

- P101: If medical advice is needed, have product container or label at hand.
- P102: Keep out of reach of children.

- P103: Read label before use.
- P201: Obtain special instructions before use.
- P202: Do not handle until all safety precautions have been read and understood.
- P210: Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
- P211: Do not spray on an open flame or other ignition source.
- P220: Keep/Store away from clothing/.../combustible materials.
- P221: Take any precaution to avoid mixing with combustibles...
- P222: Do not allow contact with air.
- P223: Keep away from any possible contact with water, because of violent reaction and possible flash fire.
- P230: Keep wetted with...
- P231: Handle under inert gas.
- P232: Protect from moisture.
- P233: Keep container tightly closed.
- P234: Keep only in original container.
- P235: Keep cool.
- P240: Ground/bond container and receiving equipment.
- P241: Use explosion-proof electrical/ventilating/lighting/.../equipment.
- P242: Use only non-sparking tools.
- P243: Take precautionary measures against static discharge.
- P244: Keep reduction valves free from grease and oil.
- P250: Do not subject to grinding/shock/.../friction.
- P251: Pressurized container: Do not pierce or burn, even after use.
- P260: Do not breathe dust/fume/gas/mist/vapours/spray.
- P261: Avoid breathing dust/fume/gas/mist/vapours/spray.
- P262: Do not get in eyes, on skin, or on clothing.
- P263: Avoid contact during pregnancy/while nursing.
- P264: Wash ﷺ thoroughly after handling.
- P270: Do not eat, drink or smoke when using this product.
- P271: Use only outdoors or in a well-ventilated area.
- P272: Contaminated work clothing should not be allowed out of the workplace.
- P273: Avoid release to the environment.
- P280: Wear protective gloves/protective clothing/eye protection/face protection.
- P281: Use personal protective equipment as required.
- P282: Wear cold insulating gloves/face shield/eye protection.
- P283: Wear fire/flame resistant/retardant clothing.
- P284: Wear respiratory protection.
- P285: In case of inadequate ventilation wear respiratory protection.
- P231 + P232: Handle under inert gas. Protect from moisture.
- P235 + P410: Keep cool. Protect from sunlight.
- P301: IF SWALLOWED:
- P302: IF ON SKIN:
- P303: IF ON SKIN (or hair):
- P304: IF INHALED:
- P305: IF IN EYES:
- P306: IF ON CLOTHING:

- P307: IF exposed:
- P308: IF exposed or concerned:
- P309: IF exposed or if you feel unwell:
- P310: Immediately call a POISON CENTER or doctor/physician.
- P311: Call a POISON CENTER or doctor/physician.
- P312: Call a POISON CENTER or doctor/physician if you feel unwell.
- P313: Get medical advice/attention.
- P314: Get medical advice/attention if you feel unwell.
- P315: Get immediate medical advice/attention.
- P320: Specific treatment is urgent (see ... on this label).
- P321: Specific treatment (see ... on this label).
- P322: Specific measures (see ... on this label).
- P330: Rinse mouth.
- P331: Do NOT induce vomiting.
- P332: If skin irritation occurs:
- P333: If skin irritation or rash occurs:
- P334: Immerse in cool water/wrap in wet bandages.
- P335: Brush off loose particles from skin.
- P336: Thaw frosted parts with lukewarm water. Do no rub affected area.
- P337: If eye irritation persists:
- P338: Remove contact lenses, if present and easy to do. Continue rinsing.
- P340: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
- P341: If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing.
- P342: If experiencing respiratory symptoms:
- P350: Gently wash with plenty of soap and water.
- P351: Rinse cautiously with water for several minutes.
- P352: Wash with plenty of soap and water.
- P353: Rinse skin with water/shower.
- P360: Rinse immediately contaminated clothing and skin with plenty of water before removing clothes.
- P361: Remove/Take off immediately all contaminated clothing.
- P362: Take off contaminated clothing and wash before reuse.
- P363: Wash contaminated clothing before reuse.
- P370: In case of fire:
- P371: In case of major fire and large quantities:
- P372: Explosion risk in case of fire.
- P373: DO NOT fight fire when fire reaches explosives.
- P374: Fight fire with normal precautions from a reasonable distance.
- P375: Fight fire remotely due to the risk of explosion.
- P376: Stop leak if safe to do so.
- P377: Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
- P378: Use ... for extinction.
- P380: Evacuate area.
- P381: Eliminate all ignition sources if safe to do so.
- P390: Absorb spillage to prevent material damage.

- P391: Collect spillage.
- P301 + P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.
- P301 + P312: IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
- P301 +P330 + P331: IF SWALLOWED: rinse mouth. Do NOT induce vomiting.
- P302 + P334: IF ON SKIN: Immerse in cool water/wrap in wet bandages.
- P302 + P350: IF ON SKIN: Gently wash with plenty of soap and water.
- P302 + P352: IF ON SKIN: Wash with plenty of soap and water.
- P303 + P361 + P353: IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
- P304 + P340: IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
- P304 + P341: IF INHALED: If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing.
- P305 + P351 + P338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
- P306 + P360: IF ON CLOTHING: rinse immediately contaminated clothing and skin with plenty of water before removing clothes.
- P307 + P311: IF exposed: Call a POISON CENTER or doctor/physician.
- P308 + P313: IF exposed or concerned: Get medical advice/attention.
- P309 + P311: IF exposed or if you feel unwell: Call a POISON CENTER or doctor/physician.
- P332 + P313: If skin irritation occurs: Get medical advice/attention.
- P333 + P313: If skin irritation or rash occurs: Get medical advice/attention.
- P335 + P334: Brush off loose particles from skin. Immerse in cool water/wrap in wet bandages.
- P337 + P313: If eye irritation persists: Get medical advice/attention.
- P342 + P311: If experiencing respiratory symptoms: Call a POISON CENTER or doctor/physician.
- P370 + P376: In case of fire: Stop leak if safe to do so.
- P370 + P378: In case of fire: Use ... for extinction.
- P370 + P380: In case of fire: Evacuate area.
- P370 + P380 + P375: In case of fire: Evacuate area. Fight fire remotely due to the risk of explosion.
- P371 + P380 + P375: In case of major fire and large quantities: Evacuate area. Fight fire remotely due to the risk of explosion.
- P401: Store ...
- P402: Store in a dry place.
- P403: Store in a well-ventilated place.
- P404: Store in a closed container.
- P405: Store locked up.
- P406: Store in corrosive resistant/... container with a resistant inner liner.
- P407: Maintain air gap between stacks/pallets.
- P410: Protect from sunlight.
- P411: Store at temperatures not exceeding ... oC/...oF.

- P412: Do not expose to temperatures exceeding 50 oC/122oF.
- P413: Store bulk masses greater than ... kg/... lbs at temperatures not exceeding ... oC/...oF.
- P420: Store away from other materials.
- P422: Store contents under...
- P402 + P404: Store in a dry place. Store in a closed container.
- P403 + P233: Store in a well-ventilated place. Keep container tightly closed.
- P403 + P235: Store in a well-ventilated place. Keep cool.
- P410 + P403: Protect from sunlight. Store in a well-ventilated place.
- P410 + P412: Protect from sunlight. Do no expose to temperatures exceeding 50 celcius degrees.
- P411 + P235: Store at temperatures not exceeding ...Keep cool.
- P501: Dispose of contents/container to...

Example GHS label:

3.2.2 User Supplied Chemicals

A user may provide their own chemicals for use in the lab after meeting the following conditions:

1 Approval for use. The chemical must be approved to be used on at least one tool in WCAM and must be an unopened and new container (exceptions to this rule must be

approved by lab management). If it is not a Materials Request Form must be filled out and approved before bringing the new chemical into the lab.

2 Each chemical will be stored in its original container or in a labeled secondary container.

3 The user will be responsible for disposal of any surplus, personal chemicals. Once brought into WCAM the chemical may never leave the lab except by proper disposal.

4 Labels: the user should obtain an HMIS and user identification labels from the chemical hygiene officer to be applied to the container before entering the lab.

For an in depth explanation of rules for chemicals being transported into WCAM, see the document: **WCAM-013.R1 Chemical Transport into WCAM**.

User Name and Email: _____

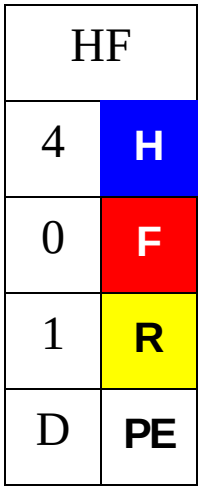
_____

Telephone #: _____

Advisor: _____

Date: _____

DISPOSAL OF THIS CHEMICAL IS THE RESPONSIBILITY OF USER.



Example of a label for hydrofluoric acid

3.3 Safety Data Sheets (SDS)

3.3.1 The SDS Description

An SDS is a form prepared by the manufacturer of the chemical, gas or material. The SDS provides additional information to the warning labels of the chemical or gas. The key information provided on the document and standardized by GHS includes:

Section 1, Identification includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.
Section 2, Hazard(s) identification includes all hazards regarding the chemical; required label elements.
Section 3, Composition/information on ingredients includes information on chemical ingredients; trade secret claims.
Section 4, First-aid measures includes important symptoms/effects, acute, delayed; required treatment.
Section 5, Fire-fighting measures lists suitable extinguishing techniques, equipment; chemical hazards from fire.
Section 6, Accidental release measures lists emergency procedures; protective equipment; proper methods of containment and cleanup.
Section 7, Handling and storage lists precautions for safe handling and storage, including incompatibilities.

Section 8, Exposure controls/personal protection lists OSHA's Permissible Exposure Limits (PELs); ACGIH Threshold Limit Values (TLVs); and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the SDS where available as well as appropriate engineering controls; personal protective equipment (PPE).
Section 9, Physical and chemical properties lists the chemical's characteristics.
Section 10, Stability and reactivity lists chemical stability and possibility of hazardous reactions.
Section 11, Toxicological information includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
Section 12, Ecological information*
Section 13, Disposal considerations*
Section 14, Transport information*
Section 15, Regulatory information*
Section 16, Other information, includes the date of preparation or last revision.

3.3.2 Location of SDS
Binders containing the SDS for each chemical, gas and material used in the WCAM lab are in two locations:

- Cleanroom gowning area, ECB Room 3039, complete listing
- Maintenance room, ECB Room 3048, partial listing of chemicals and gases of concern
- Fire control room, ECB Room M1069, partial listing of chemicals and gases of concern
- Chemical storage room, ECB Room 3042, complete listing of chemicals in storage room
- WCAM's website, complete listing of electronic files

3.3.3 SDS Terms and Definitions, abbreviated listing:
ACGIH---American Conference of Governmental Industrial Hygienists, Inc.: an organization of professional personnel in governmental agencies or educational institutions engaged in occupational safety and health programs. ACGIH develops and publishes recommended occupational exposure limits (see TLV) for hundreds of chemical substances and physical agents.
Acute Toxicity---The adverse (acute) effects resulting from a single dose of, or exposure to, a substance. Ordinarily used to denote effects in experimental animals.
Alopecia---Loss of hair.
Analgesia---Loss of sensitivity to pain.
Anesthesia---Loss of sensation or feeling.
Anhydride---An oxide or compound that, when combined with water, gives an acid or base.
Anhydrous---Free of water.
Anorexia---Loss of appetite.
Anosmia---Loss of the sense of smell.
Anoxia---A lack of oxygen from inspired air (literally without oxygen). See Hypoxia.
Aqueous---A water-based solution.
Asphyxia---Lack of oxygen and thus interference with the oxygenation of the blood. Can lead to unconsciousness.
Asphyxiant---A vapor or gas that can cause unconsciousness or death by suffocation (lack of oxygen). Most simple asphyxiants are harmful to the body only when they become so concentrated that they reduce oxygen in the air (normally about 21%) to dangerous levels (18%

or lower). Asphyxiation is one of the principal potential hazards of working in confined spaces.
Asphyxiation---A condition that causes asphyxia; suffocation.
Asthma---A disease characterized by recurrent attacks of dyspnea, wheezing, and perhaps coughing due to spasmodic contraction of the bronchioles.
Asymptomatic---Neither causing nor exhibiting symptoms.
Ataxia---A loss of muscular coordination.
Atrophy---A wasting or diminution in the size of tissues, organs, or the entire body.
Autoignition Temperature---The minimum temperature to which a substance must be heated without application of a flame or spark in order to cause that substance to ignite.
BEI---Biological Exposure Indices: reference values for chemicals which may be identified in blood, urine or exhaled air intended to be used as guidelines for evaluation of potential health hazards by industrial hygienists.
Bradycardia---A slow heartbeat. Pulse rate below 60.
Bronchitis---Inflammation of the bronchial tubes in the lungs.
Carcinogen---A substance determined to be cancer-producing or potentially cancer-producing by OSHA, the International Agency for Research on Cancer, or the National Toxicology Program.
Carcinoma---A malignant tumor or cancer; a new growth made up of epithelial cells, tending to infiltrate other tissue and give rise to metastases.
Cataract---A loss of transparency of the lens of the eye or of its capsule.
Chronic Health Effect---An adverse health effect with symptoms that develop slowly over a long period of time or that recur frequently.
Chronic---Lasting a long time, or recurring.
Combustible---A term used by NFPA, DOT, and others to classify certain liquids that will burn, on a basis of flash points. Both NFPA and DOT generally define combustible liquids as having a flash point of 100°F (37.8°C) or higher. See also Flammable. Non-liquid substances such as wood and paper are classified as ordinary combustibles by NFPA.
Conjunctivitis---Inflammation of the conjunctiva, the delicate membrane that lines the eyelids and covers the eyeballs.
Corrosive---A chemical that has a pH less than 2, or greater than 12.5 or that causes visible destruction of, or irreversible alternations in, living tissue by chemical action at the site of contact; or in the case of leakage from its packaging, a liquid that has a severe corrosion rate on steel. A solid or liquid waste that exhibits a "characteristic or corrosivity," as defined by RCRA, may be regulated (by EPA) as a hazardous waste.
Cutaneous---Pertaining to the skin.
Cyanosis---A dark purplish coloration of the skin and the mucous membrane due to the deficient oxygenation of the blood.
Decomposition---Breakdown of a material or substance (by heat, chemical reaction, electrolysis, decay, or other processes) into parts or elements or simpler compounds.
Dermal---Used on or applied to the skin.
Dermal Toxicity---Adverse effects resulting from the skin's exposure to a substance.
Dermatitis---Inflammation of the skin.
Diaphoresis---Perspiration.
Dyspnea---A sense of difficulty in breathing; shortness of breath.
Edema---An abnormal accumulation of fluid in the tissues.
Electrolyte---Any substance that conducts an electric current in solution.

Embolism---Obstruction of a blood vessel by a transported clot, a mass of bacteria, or other foreign material.
Emphysema---A disease of the lungs in which the air sacs become distended and lose elasticity.
Epistaxis---Nosebleed; hemorrhage from the nose.
Evaporation Rate---The rate at which a particular material will vaporize (evaporate) when compared to the rate of vaporization of a known material. The known material is usually normal butyl acetate (NBUAC or n-BuAc), with a vaporization rate designated as 1.0. Vaporization rates of other solvents or materials are then classified as: FAST evaporating if greater than 3.0. MEDIUM evaporating if 0.8 to 3.0. SLOW evaporating if less than 0.8.
Explosive---A material that can undergo a rapid violent change such as a sudden, almost instantaneous release of pressure, gas, and heat.
Fibrosis---Formation of fibrous tissue, as in a reparative or reactive process, in excess of amounts normally present.
Flammable---Describes any solid, liquid, vapor, or gas that will ignite easily and burn rapidly. A flammable liquid is defined by NFPA and DOT as a liquid with a flash point below 100°F (37.8°C).
Flammable Aerosol---An aerosol that yields a flame projection of 18 inches at the full valve opening, or a flashback at any degree of valve opening when tested per 16 CFR 1500.45.
Flammable Solids---Solids that will ignite readily or are liable to cause fires under ordinary conditions or transportation through friction or retained heat from manufacturing or processing, and that burn so vigorously and persistently as to create a serious transportation hazard, are classified by DOT as Flammable Solids. See also Combustible.
Flammable Limits---The minimum and maximum concentrations of a flammable gas or vapor between which ignition can occur. Concentrations below the lower flammable limit (LFL) are too lean to burn, while concentrations above the upper flammable limit (UFL) are too rich. All concentrations between LFL and UFL are in the flammable range, and special precautions are needed to prevent ignition or explosion.
Flash Point---Lowest temperature at which a flammable liquid gives off sufficient vapors to form a flammable mixture with air.
Gangrene---Death of tissue combined with putrefaction.
Gastroenteritis---Inflammation of the stomach and intestines.
Gingivitis---Inflammation of the gums.
Hematuria---The presence of blood in the urine.
Hepatic---Pertaining to the liver.
Highly Toxic---Having (a) an LD50 of 50 mg/kg or less when administered to albino rats weighing 200-300 grams each, (b) an LD50 of 200 mg/kg or less when administered by continuous contact for 24 hours with the bare skin of albino rabbits weighing 2-3 kilograms, or (c) an LC50 in air of 200 ppm or less (gas or vapor) or 2 mg/l or less (mist, fume, or dust) when administered by continuous inhalation for one hour to albino rats weighing 200-300 grams each.
Hygroscopic---Readily absorbs moisture.
Hypergolic---Describing rocket fuel or propellant that consists of combinations of fuels and oxidizers that ignite spontaneously on contact.
Hypoxia---Insufficient oxygen, especially applied to body cells.
IDLH---Immediately Dangerous to Life and Health- means an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere.

Inflammation---A series of reactions produced in the tissues by an irritant, injury, or infection characterized by redness and swelling caused by an influx of blood and fluids.
Ingestion---The taking in of a substance through the mouth.
Inhalation---The breathing in of a substance in the form of a gas, vapor, fume, mist, or dust.
Iridocyclitis---Inflammation of both iris and ciliary body.
Irritant---A chemical that causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.
Jaundice---Yellowish discoloration of tissues (skin), whites of eyes (sclerae), and bodily fluids with bile pigment (bilirubin) caused by any of several pathological conditions that interrupt liver function.
Ketosis---The condition marked by excessive production or accumulation of ketone bodies in the body.
Lacrimation---Secretion and discharge of tears.
LC50---Lethal Concentration 50: The concentration of a material in air that, on the basis of laboratory tests, is expected to kill 50% of a group of test animals when administered as a single exposure (usually 1 or 4 hours). The LC50 is expressed as parts of material per million parts of air, by volume (ppm) for gases and vapors, or as micrograms of material per liter of air (µg/L) or milligrams of material per cubic meter of air (mg/m3) for dusts and mists, as well as for gases and vapors.
LD50---Lethal Dose 50: A single dose of a material that, on the basis of laboratory tests, is expected to kill 50% of a group of test animals. The LD50 dose is usually expressed as milligrams or grams of material per kilogram of animal weight (mg/kg or g/kg).
Lesion---Abnormal change, injury, or damage to tissue or to an organ.
Leukemia---A progressive, malignant disease of the blood-forming organs.
Malaise---A feeling of general discomfort, distress, or uneasiness; an out-of-sorts feeling.
Mutagen---A chemical or physical agent that induces genetic mutations.
Narcosis---Stupor or unconsciousness produced by a narcotic drug.
Nausea---Tendency to vomit, feeling of sickness at the stomach.
Necrosis---Local death of tissue.
Neoplasm---A new or abnormal growth of tissue in which the growth is uncontrolled and progressive.
Nystagmus---Spastic, involuntary motion of the eyeballs in a horizontal, rotary, or vertical direction.
Oliguria---Scanty or low volume of urine.
Oxidation---A reaction in which a substance combines with oxygen or a reaction in which electrons are transferred (as in an oxidation-reduction reaction).
Palpitation---Irregular, rapid heartbeat.
PEL---Permissible Exposure Limit: An exposure limit established by OSHA. May be a time-weighted average (TWA) limit or a maximum concentration exposure limit.
pH---The value that represents the acidity or alkalinity of an aqueous solution. Pure water has a pH of 7. The strongest acids have an excess of H+ and OH- ions. For example, the strongest acids have an excess of H+ ions and a pH of 1 to 3 (HC1, pH=1). The strongest bases have an excess of OH- ions and a pH of 11 to 13 (NaOH, pH = 12).
Phlegm---Thick mucous from the respiratory passages.
Pneumoconiosis---The accumulation of dust in the lungs and the tissue reaction to its presence.
Polymerization---A chemical reaction in which one or more small molecules combine to form

larger molecules. A hazardous polymerization is such a reaction that takes place at a rate that releases large amounts of energy.
Prostration---Physical exhaustion and incapacitation.
Pulmonary Edema---Fluid in the lungs.
Respiratory System---The lungs and air passages (trachea or "windpipe", larynx, mouth, and nose), as well as the associated nervous and circulatory supply.
Sclerae---The tough, white, fibrous covering of the eyeball.
Sensitization---An immune response in which initial exposure causes little or no response but subsequent exposure elicits elevated response due to an immune or allergic response.
Sensitizer---A substance that, on first exposure, causes little or no reaction in man or test animals, but which on repeated exposure may cause a marked response not necessarily limited to the contact site. Skin sensitization is the most common form of sensitization in the industrial setting, although respiratory sensitization to a few chemicals is also known to occur.
"Skin"---Notation used to indicate possible significant contribution to overall exposure to a chemical by way of absorption through the skin, mucous membranes, and eyes by direct or airborne contact.
Spasm---An involuntary, convulsive muscular contraction.
STEL---Short-Term Exposure Limit: ACGIH terminology. See TLV-STEL.
Stupor---Partial or nearly complete unconsciousness.
Subcutaneous---Beneath the skin.
Systemic---Affecting the entire body.
Tachycardia---Excessively rapid heartbeat. Pulse rate above 100.
Target Organ Effects---Chemically caused effects upon organs and systems such as the liver, kidneys, nervous system, lungs, skin, and eyes from exposure to a material.
Teratogen---An agent or substance that causes physical defects in the developing embryo.
Tinnitus---A ringing sound in the ears.
TLV---Threshold Limit Value: A term used by ACGIH to express the airborne exposure level to a chemical or physical hazard to which nearly all persons can be exposed day after day without adverse effects. ACGIH expresses TLVs in three ways:

- **TLV-TWA:** The allowable Time-Weighted Average level for a normal 8-hour workday or 40-hour week.
- **TLV-STEL:** The Short-Term Exposure Limit or maximum level for a continuous 15-minute exposure period (maximum of four such periods per day, with at least 60 minutes between exposure periods, and provided that the daily TLV-TWA is not exceeded).
- **TLV-C:** The Ceiling Exposure Limit - the level that should not be exceeded during any part of the working exposure.

Toxic--Having (a) an LD50 of 50-500 mg/kg when administered orally to albino rats weighing 200-300 grams each, (b) an LD50 of 200-1000 mg/kg when administered by continuous contact for 24 hours with the bare skin of albino rabbits weighing 2-3 kilograms each, or (c) an LC50 of 200-2000 ppm (gas or vapor) or 2-20 mg/1 (mist, fume or dust) when administered by continuous inhalation for one hour to albino rats weighing 200-300 grams each.
Urticaria---Nettle-rash; hives; elevated, itching, white patches.
Vertigo---A feeling of revolving in space; dizziness, giddiness.
Viscosity---The internal resistance to flow exhibited by a fluid.

Chemical Hygiene Plan
IV. Hazard Prevention and Chemical Exposure Controls

4.1 Engineering Controls

4.1.1 Compressed Gas Handling Protocol

Section 1. Compressed Gas Definition
Compressed gas is any gas or mixture of gases in a container with a pressure exceeding 40.6 psi at 68°F (20°C). The container will be filled and maintained by the supplier and in compliance with all DOT regulations. The container will be properly marked and labeled in accordance with DOT and OSHA standards.

Section 2. Procedure/Operation.
Only authorized staff personnel will have access to the gas cylinders and gas cabinets. They will be trained with a thorough knowledge of the products and their hazards; with the proper care, inspection and use of the valve and its connections; with the proper knowledge of the gas and purge panel valves and controls; and with the proper personal protective clothing.

Only trained users will have access to the processing tool that utilizes the compressed gases. They will be trained with a thorough knowledge of the products and their hazards; with the proper care, inspection and use of processing system; and with proper emergency response and shutdown procedures. The lab users will **not** have access to the gas cabinets and delivery systems, only trained staff members of WCAM. Gas cylinders will never be changed out by one staff member, and two staff members should always be present for a cylinder change.

When gas cylinders are moved they will never be unattended, strapped to a gas cylinder cart via metal chain, and the cylinder cap must be on.

Section 3. Personal Protective Equipment.
For any operation that requires the removal of the cylinder valve protection cap, the changing out of compressed cylinders, or exposure to the compressed gas cylinder, the recommended personal protective equipment is:

- Safety glasses

For Emergency Response situations:

- Polyethylene or equivalent full body protection with hood or equivalent head protection.
- Self Contained Breathing Apparatus.
- Acid resistant hand protection.
- Acid resistant shoe covers

Section 4. Emergency Action.

Any laboratory user will be able to recognize any hazards and initiate the proper response. They should be familiar with the location and operation of necessary emergency equipment, including but not limited to phones, emergency showers and eye washes, alarms, the emergency response cart and the like. Emergency response and equipment training of all persons will be documented and a record file maintained. See ***Section 8.1 Hazard Exposure*** for emergency response procedure for exposure to chemical hazards. See ***Section 8.5 Toxic Gas Alarm*** for the emergency response procedure for the detection of compressed gas hazards.

Section 5. Hazardous Materials Definition.
This procedure applies to all compressed gases. Several types of compressed gases are defined as hazardous materials. The following definitions apply:

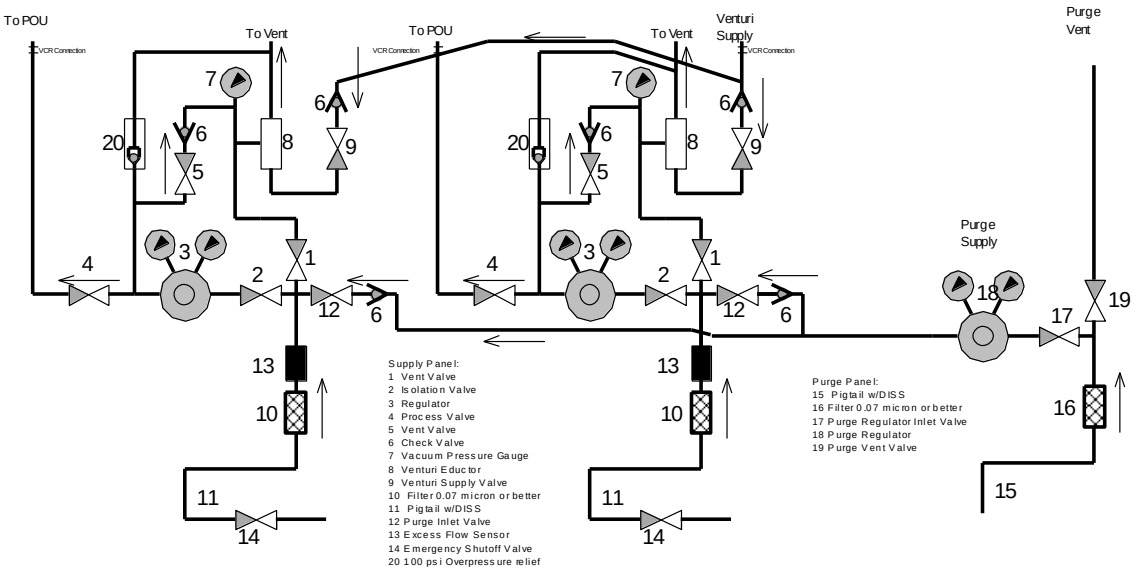
- Highly toxic gases include:
    - Gases that have a median Lethal Concentration (LC50) in air of 200 ppm or less by volume of gas or vapor.
    - A threshold Limit Value (TLV) as established by ACGIH or a Permissible Exposure Level as established by OSHA, less than or equal to 1 ppm.
    - Designated as a "Poison A" by the DOT.
    - Examples include: phosphine, chlorine, and dicholorsilane.
- Toxic gases include:
    - Gases that have a median Lethal Concentration (LC50) in air of more than 200 ppm and less than 2000 ppm by volume of gas or vapor.
    - A threshold Limit Value (TLV) as established by ACGIH or a Permissible Exposure Level as established by OSHA, more than 1 ppm but less than 50 ppm.
    - Examples: Ammonia, boron trichloride, and hydrogen chloride.
- Flammable gases include:
    - Gas that at ambient temperature and pressure forms a flammable mixture with air at a concentration of 12 percent (or less) by volume.
    - Examples: Hydrogen.
- Pyrophoric gases include:
    - Gases that will usually ignite spontaneously in contact with air at a temperature of 130 F or below.
    - Examples: Silane.

Section 6. Gas Containment and Delivery Systems
Gas Cabinet and valves. For all Hazardous gases, the cylinder will be placed in a ventilated gas cabinet specially designed for compressed gas use. The exhaust system will provide a minimum of 200 fpm across the cylinder neck, all unwelded fittings, and the enclosure opening. The exhaust fans will be connected to the building emergency power. A remote emergency shutdown system (**ESS**) must be present on hazardous gas delivery panels. An excess-flow valve or excess-flow switch must be installed on hazardous gas delivery panels to shut off flow in case of a down-stream rupture. This valve will be located as close to the source as possible. Manual cylinder valves will be

used for operation. A dedicated inert gas purge cylinder of **Helium,** for each gas enclosure containing a hazardous gas, will be used for purging operations.
The gas cabinet system will consist of:

1. All regulators must be ultra high purity tied diaphragm regulators
2. All valves must be ultra high purity springless diaphragm valves equivalent to Swagelok DP series.
3. All tubing and gas fittings must be 10 RA maximum electro-polished.
4. All gas fittings must be VCR typeface seal.
5. Must have automatic emergency shut-off capability per **SEMI specification F13-93.** The process panel will have an emergency shutoff valve located immediately after the cylinder connection. The ESO will close the gas connection upon:
    a. Manual actuation of Emergency OFF switch,
    b. Electrical activation via the toxic gas monitor alarm,
    c. Internal activation via the process panel due to: excess pressure or excess flow.
    d. Heat detected by IR sensor in flammable gas cabinets
6. Assembly must be helium leak tested to better than 1×10^{-8} Atm-cc/sec.
7. Must conform to ***SEMI specification F14-93***.
8. Must have semi-automatic process panel(s) conforming to ***SEMI specification F22-0697 section 7***. Exception is that we will use Helium for the purge gas not Nitrogen as indicated in the specification.
9. Check valves to be all welded equivalent to Swagelok "CW" series.
10. The cylinder connection shall be a DISS type metal seal connection.
11. The process panel will have an overpressure relief valve, located immediately after the regulator.
12. The process panel will have an excess flow sensor capable of closing the ESO valve upon sensing an excess flow
13. The process panel will have a Venturi vacuum system to purge the cylinder connections
14. In the case of flammable gases, the cabinet will have an infrared flame detector interconnected with a water sprinkler (located in the gas cabinet)
15. A gas cabinet shall have a unique purge cylinder located within the same enclosure.
16. Figure 1 depicts a typical gas cabinet process panel.

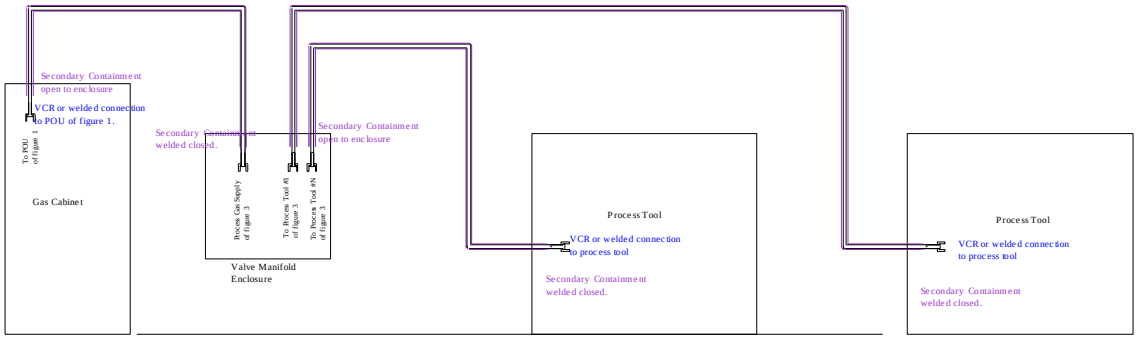
Figure 1. Typical gas panel located within a gas cabinet.



Gas Distribution system. All gas lines will be labeled with the appropriate gas name at every 6 feet of pipe run and at every penetration to a containment system or other barrier.

Primary Containment Piping. All non-hazardous gases will be piped in electro-polished, stainless steel tubing. The tubing will be joined via orbital tube welding in accordance with SEMI F3 Guide for Welding Stainless Steel Tubing for Semiconductor Manufacturing Applications.

Figure 2. Typical Secondary Containment Piping



Secondary Containment Piping. All hazardous gases will be piped in electro-polished, stainless steel tubing in accordance with ***SEMI F6 Guide for Secondary Containment of Hazardous Gas Piping Systems***. The tubing will be joined via orbital tube welding in accordance with ***SEMI F3 Guide for Welding Stainless Steel Tubing for Semiconductor Manufacturing Applications***. The piping will be helium leak checked to better than $1x10^{-10}$ kPa-L/sec in accordance with ***SEMI F1 Specification for Leak Integrity of High-purity Gas Piping Systems and Components***. Only VCR typeface seal fittings shall be used for the mechanical connection of the gas lines. All VCR connections of the primary pipe will occur within an exhausted secondary containment cabinet. A typical installation is depicted in figure 2.

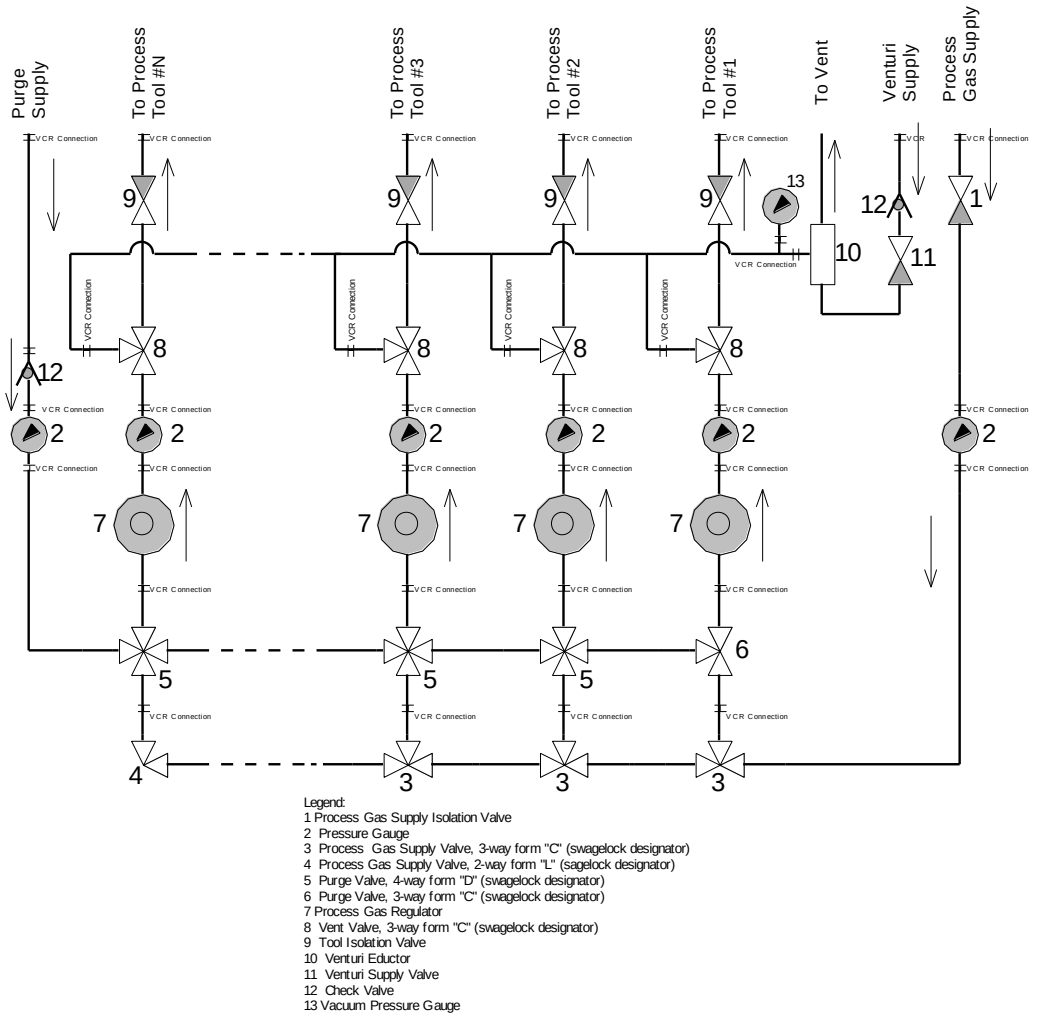
- The persons performing the tube welding will be certified by the manufacturer of the tube welding tool for the installation of electropolished, stainless steel tubing.
- The certification shall be current (within the last 2 years of issue) and each welder shall present their certification identifying the individual by name and date of certification.
- All welders must have at least 5 years of experience installing ultra-high purity gas piping systems The welded tubing will be leak checked in accordance with:
    - SEMI F6 Guide for Secondary Containment of Hazardous Gas Piping Systems.
    - SEMI F1 Specification for Leak Integrity of High-purity Gas Piping Systems and Components
    - SEMI F3 Guide for Welding Stainless Steel Tubing for Semiconductor Manufacturing Applications.
    - ASME Section IX.

Valve Manifold Enclosures. Valve manifold enclosures will be utilized to distribute gases from a single gas source to multiple use points. The enclosure will pipe incoming process gas to several outgoing Point of Use gas lines. The exhaust system will provide a minimum of 200 fpm across all non-welded fittings, and the enclosure opening. The exhaust fans will be connected to the building emergency power.

Figure 3 depicts a typical process panel within a valve manifold enclosure. The Valve Manifold Enclosure will consist of:

1. All regulators must be ultra high purity tied diaphragm regulators equivalent to Tescom series 74-2400.
2. All valves must be ultra high purity springless diaphragm valves equivalent to Swagelok DP series.
3. All tubing and gas fittings must be 10 RA maximum electro-polished.
4. All gas fittings must be VCR typeface seal.
5. Assembly must be helium leak tested to better than 1×10^{-8} Atm-cc/sec.
6. Must conform to ***SEMI specification F14-93***.
7. Check valves to be all welded equivalent to Swagelok "CW" series.
8. The process panel will have a Venturi vacuum system to purge the cylinder connections.
9. In the case of flammable gases, the cabinet will have an infrared flame detector interconnected with a water sprinkler (located in the manifold cabinet)

Figure 3. Typical Valve Manifold Enclosure



Section 7. Gas Monitors and Alarms

Description: An MDA Scientific CM4 Continuous Toxic Gas Monitor (TGM) will be used to monitor gas concentrations for each hazardous gas that is utilized in WCAM. This system continuously samples the atmosphere and triggers alarms at two programmed concentration levels. Gas detector sensor locations will be inside the gas cabinet, in the room outside of the gas cabinet, and at the tools that use the gas. For an in depth explanation of the TGM system and staff response, see the document: **WCAM-011.R1 TGM Evacuation & Response**.

Gas detector alarm levels:

- ***ALARM Level 1*** for detection of gas leak which does not require external emergency response. This will be programmed at the Threshold Limit Value, TLV, for toxic gases and 20% of the flammability limit for flammable gases.
- ***ALARM Level 2*** for a leak requiring emergency response. This will be programmed at 2X the Threshold Limit Value, TLV, for toxic gases and 50% of the flammability limit for flammable gases.

Alarm Actions: If a gas is detected above the alarm levels the gas monitor sensor sends a signal to:

- Engineering Centers Building Simplex system (located in the building fire control room M1069)
- ESS control on the gas cabinet of the gas to initiate closing of the Emergency Shutoff Valve at the gas bottle.

The building's Simplex system communicates to the University's Metasys system; which in turn notifies the continuously attended control station at the UW Police Dept. The system notification will include what type of gas is leaking and the location. The Simplex system sounds building alarms in the following manner:

- For an ***ALARM Level 1***, TGM audible and visual indicators in and near the clean room will sound. The building fire alarms will **not**.
- For an ***ALARM Level 2***, TGM audible and visual indicators in and near the clean room will sound as well as the building fire alarms.

Emergency power. The Toxic Gas Monitor system will be connected to the building emergency power system.

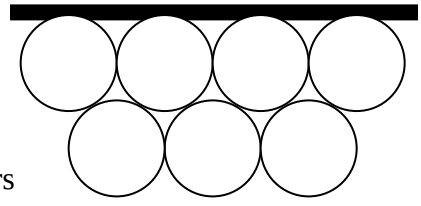
System Maintenance. The paper cassette in each MDA CM-4 unit will require changing approximately every 90 days. This will be done in accordance with the procedure in Section 9 of the MDA Manual. All detectors, monitors, and alarms shall be maintained in working condition in accordance with IFC 2703.2.6.

Section 8. Cylinder Storage and Handling

WCAM will maintain all gas cylinders and will not modify, tamper with or repair any part of the cylinder. WCAM will also properly transport, store and install the cylinders in accordance with regulations and standard practices.

- Cylinders will be chained in a cylinder cart to transport.
- Valve protection caps will be secured on the cylinder at all times, except when the cylinder is in use.
- Cylinders will not be used as rollers, supports, or for any purpose other than to contain and use the contents as received.
- Cylinders will not be placed where they can become part of an electrical circuit.
- Cylinders will not be exposed to extreme temperatures.
- Suppliers will be notified of damaged, defective or leaking containers.

Storage. Spare cylinders will only be stored in the gas cylinder storage room. The cylinders will be chained in an upright position to the wall-mounted rack based on the three-point contact system. While in storage the cylinder valve protection cap must be in place at all times. Cylinders will be segregated by classification: corrosive, inert, oxidizer, and toxic.



Three-point contact system

Transporting a Cylinder. Always move cylinders by hand trucks designed for that purpose and never transport a cylinder without its valve protection cap firmly in place and being chained to the cart. If a cylinder must be moved via a freight elevator, personnel should not ride in the elevator with the cylinder.

Cylinder Change. All cylinder changes will be accomplished by two WCAM staff members and in accordance with the procedure given in section 5.3.8 of the gas cabinet vendors manual. ***(See Appendix A.)***

4.1.2 Wet Benches

The chemical wet benches are equipped with photohelic monitors to measure the exhaust static pressure at the bench. If at any time the pressure drops below the prescribed limit, the bench will issue an audible and visual alarm and electrical power to the wet bench's electrically active components will be cutoff. Users are instructed to cease processing at the wet bench until exhaust has been re-established to the proper level. Wet benches will be certified on a yearly basis for proper exhaust by the UW Physical Plant. All wet benches will have a UW-Madison exhaust hood evaluation sticker affixed.

4.1.3 Equipment EMO or EPO

Each system in the lab will have a red palm shaped button designated as an **E**mergency **M**achine **O**ff (EMO) circuit. The EMO when activated will shut down all electrical components of the system and place the system in a safer condition than if it were running. A safe shutdown should not increase the level of hazard in the system. The EMO circuit will be a failsafe circuit that shuts off all electrical power to the equipment so that only the EMO circuit and its supply may be energized. The EMO circuit will require manual resetting so that the power cannot be restored automatically.

4.1.4 Equipment Computer Security System

Most of the equipment in the lab will be interfaced to the computer security system for the lab. The current cleanroom facility operation software is called Facility Online Manager (FOM). This system will provide two important functions for the safety of employees and users:

- The security system will only allow a previously trained user to activate each piece of equipment. Activation will be via a login with username and password. Thus, preventing unauthorized use of equipment.
- The system will also provide the first step for lock out/tag out procedures. When equipment maintenance is required, a lab employee or technician will deactivate the system's log in capability and follow lock out/tag out procedures. See ***Section 4.2.5 Equipment Lock Out/Tag Out Devices and Notices***. Only lab staff will have the ability to remove the lock out/tag out devices and be able to reactivate the computer login system for the equipment to be available to the users.

4.1.5 Emergency Eyewash and Shower Stations

When an employee or user has been exposed to chemicals the first step is to flush the affected area with water. The stations are located in every bay to the right of the door. Additionally, in bays where hydrofluoric acid is used, calcium gluconate gel is available at the station. The chemical hygiene officer will check the station operation monthly and restock the gel after use or

when expired. The chemical hygiene officer will flush the eyewash stations monthly. The UW Safety Department will conduct a yearly inspection of safety showers. A dated white tag will be attached to the unit documenting the inspection. A red tag would indicate a needed repair for the unit.

See ***Section 8.1 Hazard Exposure*** for the emergency response procedure for exposure to chemical hazards.

4.1.6 Telephones

Two telephones are located in the cleanroom. Telephone numbers of all lab facility personnel and university police will be posted near the telephone. In the case of an emergency, dialing **911** will immediately notify the University Police Dept. and they will dispatch emergency responders. Please note that dialing 911 on your cell phone will connect you to the Dane County Center, but the University Police will be contacted via the Dane County Center.

When calling 911 be prepared to:

- Identify yourself and the reason you are calling
- Identify the exact location of the emergency
- Identify the nature of the emergency
- Identify any injuries or symptoms involved
- Identify all hazardous materials involved if you know them
- Stay on the phone until the dispatcher tells you otherwise

4.2 Administrative Controls

4.2.1 Building and Facility Maintenance

Appropriate UW Physical Plant personnel will conduct scheduled inspections of building and lab systems such as:

- Air handlers
- Exhaust systems
- Water conditioning systems
- Fire extinguishers
- Fire suppression systems
- Emergency exits
- Security systems
- Eyewashes and emergency showers
- Wet bench exhaust

4.2.2 Building and Lab Signage

The building is equipped with illuminated exit signs and directions for accessible facilities. These signs are powered by an emergency power system in the event of power loss to the building.

Under normal circumstances a user exits the cleanroom via the FOM activated door to the gown room. This is not an emergency exit. Each cleanroom bay has two exits with one labeled an

emergency exit only. Each utility chase has two exits. The cleanroom chase door is labeled "Authorized Personnel Only".

The storage cabinets in the lab are designated for **FLAMMABLES** or **CORROSIVES**. Each cabinet will have a posted list of chemicals being stored. The flammable cabinets are metal and are used for solvents such as acetone and isopropyl alcohol. The corrosive cabinets are white plastic and are for acids and bases.

4.2.3 Lab Inspections

Lab employees will conduct a daily walk-through of the lab. The walk-through will identify any safety issues or general needs of the lab facility while inspecting the following:

- Cleanliness of the lab including trash containers
- Remove empty chemical bottles to be rinsed and disposed
- Storage of chemicals

The chemical hygiene officer will conduct inspection and inventory of the lab:

- Check equipment with lock out/tag out devices
- Monthly operation of the emergency eyewash stations
- Weekly record pressures of all gas cylinders installed
- Weekly check to restock chemicals, gloves and wipes
- Weekly inventory and reorder of the chemicals and lab supplies
- Quarterly inventory of emergency response items
- Yearly review of personal chemicals brought in by users

4.2.4 Equipment Maintenance

The lab user plays an important part of equipment maintenance. A lab user reporting equipment difficulties results in improved operation and less downtime for equipment. Observations during operation of equipment are to be recorded in the individual equipment logbook. If problems occur during operation, the user is to directly report the occurrence to lab staff. In the event lab employees are not available, email a report to the staff. Lab users are not allowed to maintenance or repair equipment and can only perform normal operation procedures of the equipment described in the operating procedure and staff training. Only cleanroom staff members are to maintenance or repair equipment in the lab.

Lab employees will also maintain records of equipment repair. From these records, a preventative maintenance schedule will be maintained for the lab equipment.

4.2.5 Equipment Lock Out/Tag Out Devices and Notices

Lock out/tag out procedures are for lab employees and technicians who are performing service or maintenance on the equipment. The procedures protect against exposure to unexpected energization, startup, or release of hazardous energy while working on the equipment. Minor tool changes and adjustments, and other minor servicing activities that take place during normal operations do not require these procedures, as long as employees are effectively protected by alternative measures.

The lab employee or technician should follow all of the lock out/tag out procedures:

1. Identify equipment problem or routine maintenance task.
2. At the computer security system, log in and place the equipment in the "Down" mode. This will also put a note for the equipment in the computer security system that the tool is not available for use, which lab users will be able to see.
3. Affix an identifying tag to the front of the equipment. The red tag should state "**DANGER DO NOT OPERATE**", reason for tag, the name of the person servicing the equipment, and date.
4. Affix an identifying tag to chase facilities for the equipment. The red tag should state "**DANGER DO NOT OPERATE**", reason for tag, the name of the person servicing the equipment, and date.
5. The equipment should be turned off and/or shut down according to the operation of that equipment before servicing.
6. Affix the appropriate lock out device(s) to inhibit the energy source(s). Devices are located in the utility chase Lock Out/Tag Out Box. The equipment would then be rendered safe for servicing.
7. Any gas cylinders for the equipment should be turned off. Retrieve the appropriate gas cabinet key from the locked key storage unit. Place a personnel-identifying tag on the removed key location and secure the key storage unit.
8. Test the equipment before servicing to verify safe condition for servicing.
9. After completion of service, the employee who applied the lock out and/or tag out device(s) must remove device(s) from the equipment.
10. At the computer security system, reactivate the equipment for use.
11. Complete the maintenance record for the equipment serviced.

The chemical hygiene officer will observe periodic inspection of lock out/tag out procedures during routine lab inspections. Any equipment with lock out/tag out devices will be viewed and corrections recommended to the authorized employee.

4.2.6 Equipment Operation

Operating procedures are written for equipment used in the lab facility. The written procedures are available at each equipment station, on the computer security system, and on the lab facility website. All users will receive individual training for equipment as well as instruction on the use of the Emergency Power Off (EPO) button located on the equipment. Users will be instructed how to activate the equipment via the computer security system. Once the user has completed the training and has demonstrated knowledge of the equipment safety and operating procedures, the user will be allowed to log on and operate the equipment independently.

4.2.7 Lab Supervision

The lab will be equipped with video cameras to monitor lab activity. This monitoring will ensure that safe procedures are followed and that at all times there are two persons working within the lab facility. The activity will be reviewed daily and lab users will be notified via email of any observed lab procedure infraction.

The lab computer security system will monitor and report the requirement that two users must be present in the lab during non-business hours.

4.2.8 Emergency Fire Drills
The UW Safety Department in accordance with Madison Fire Department will conduct and monitor scheduled fire drill exercises for campus facilities.

4.3 Personal Protection Equipment (PPE)

4.3.1 Use of PPE
The use of personal protective equipment is in addition to the engineering and administrative controls. The equipment is to ensure the health and safety of employees and users working in the lab. The equipment will be provided in appropriate work areas throughout the lab facility.

4.3.2 Types of PPE

- Safety glasses/goggles are to be worn at all times while working in the lab. The glasses/goggles will be located in the gowning room and is part of the donning procedures. See ***Section 7.4 Donning Procedures***.
  Exceptions: A) If a user can show proof of safety eyewear with side shields, they may forego the use of the provided lab safety glasses. B) While currently viewing into the eyepieces of an optical microscope.
- Face shields are provided in the chemical rooms. The shield is to be worn while working with corrosive chemicals.
- Chemicals gloves will be provided in the chemical rooms. The nitrile or vinyl lab gloves that are part of the donning procedures are not adequate protection against chemicals. When working with toxic and/or corrosive chemicals, the user will wear both the lab gloves and chemical gloves provided.
- Aprons will be provided in the chemical rooms. An apron will be worn while working with toxic and/or corrosive chemicals.
- Half-face respirators are provided as an optional protection to the lab staff and no fit test is required to wear them. This is a voluntary protection and not required due to the engineering controls described. See ***Section 4.3.3 Informational Statement for Voluntary Respirator Use*** and ***Section 7.3.4 Procedures for Voluntary Respirator Use*** for explanation of respirator type and use.
- Self-contained breathing apparatus (SCBA) is available for employees to perform specific maintenance procedures or emergency response. See ***Section 4.3.4 Mandatory Respirator Use***.

4.3.3 Informational Statement for Voluntary Respirator Use
Respirators are an effective method of protection against designated hazards when properly selected and worn. Respirator use is encouraged, even when exposures are below the exposure limit, to provide an additional level of comfort and protection for lab staff. However, if a respirator is used improperly or not kept clean, the respirator itself can become a hazard to the worker. Sometimes, workers may wear respirators to avoid exposures to hazards, even if the amount of hazardous substance does not exceed the limits set by OSHA standards. If your employer provides respirators for your voluntary use, or if you provide your own respirator, you need to take certain precautions to be sure that the respirator itself does not present a hazards.

You should do the following:

- Read and heed all instructions provided by the manufacturer on use, maintenance, cleaning and care, and warnings regarding the respirators limitations.
- Choose respirators certified for use to protect against the contaminant of concern. NIOSH, the National Institute for Occupational Safety and Health of the U.S. Department of Health and Human Services, certifies respirators. A label or statement of certification should appear on the respirator or respirator packaging. It will tell you what the respirator is designed for and to what extent it will protect you.

Do not wear your respirator into atmospheres containing contaminants for which your respirator is not designed to protect against. For examples, a respirator designed to filter dust particles will not protect you against gases, vapors, or very small solid particles of fumes or smoke.
Appendix D to §1910.134
(Mandatory) Information for Employees Using Respirators When Not Required Under the Standard

4.3.4 Mandatory Respirator Use
Users of the lab facility are not required to use any respirator. Numerous building and facility controls are in place to protect users.

Employees will be required to wear half-mask respirators or self-contained breathing apparatus (SCBA) during some equipment maintenance procedures or emergency response. Each employee must:

- Complete the Respirator Medical Evaluation Questionnaire. Available on-line by University Health Services. Must receive clearance from UHS to wear SCBA.
- Complete a yearly Respirator Fit Test provided by University Health Services. University Health Services sends email reminders when re-certification is nearing.
- Participation in bi-yearly practice training for SCBA equipment. Scheduled by the chemical hygiene officer.

The chemical hygiene officer will maintain all records in employee training files. University Health Services will also maintain records of fit testing and medical evaluation clearance.

4.3.5 Respirator Maintenance
Each half-face respirator will accumulate less than 30 hours of use. The cartridges will be changed yearly and the date of change will be written on the cartridges. Use and cleaning procedures of respirators are listed in ***Section 7.3.4 Procedures for Voluntary Respirator Use.***

The SCBA equipment will be maintained according to manufacturer's recommendations. When depleted, the tank will be refilled with grade D air. The harness assembly, masks, and valves will be checked every 6 months during SCBA practice training. The tank will be scheduled for hydrostatic testing every five years.

Chemical Hygiene Plan
V. Rules and Policies

User Lab Rules and Policies
The following is a list of rules and policies that all users agree to abide by. This list is intended to include the most common problems but user responsibilities are not limited to this list.

5.1 Access

- A user must complete the WCAM safety course and pass the quizzes prior to access being granted.
- A user must complete an onsite orientation for the cleanroom with a staff member prior to access being granted.
- To keep their lab access a user must complete at least 1 safety renewal session per year held by the WCAM staff.
- To keep their lab access a user must follow the lab rules and safety procedures.
- A user may only access the lab and equipment using only their UW ID card or FOM account.
- Never prop open any doors from the gown room to the outside hallway or from the gown room to the cleanroom corridor.
- A user must log into FOM to enter the cleanroom.
- Every user in the cleanroom must be logged into FOM.
- A user must log out of FOM to exit from the clean room to the gown room.
- It is the responsibility of the user and/or their principle investigator to notify the staff when a user no longer will be using the lab.
- It is the responsibility of the user to return their keys prior to their lab account closing.
- It is the responsibility of the user to remove any of their personal items, including personal chemicals, prior to their lab account closing.
- A fee may be charged if staff must dispose of personal chemicals abandoned by inactive users.

5.2 General Safety

- Call **911** in the event of an emergency.
- Understand the different lab alarms: fire, toxic gas, and weather.
- Know the evacuation procedure for the cleanroom.
- LONE WORKER RULE, during non-UW business hours there must be two or more users logged into and present in the cleanroom when it is in use.
- Wear safety glasses/goggles at all times within the lab.
- Wear protective footwear with non-skid soles. Sandals or open-toed shoes are prohibited.
- Know the locations of the eyewashes, showers, fire extinguishers, telephones, first aid kits and Emergency Response Cart.
- Understand proper use of eyewashes, body showers, and fire extinguishers
- Notify staff of any equipment problems, chemical spills or accidents.
- Lab users shall not enter the utility chases.
- Work in the lab only when others are within shouting distance.
- Do not move gas cylinders without cylinder caps and being safely chained to a cart.
- PLASMA RULE, Do not leave any deposition or etching system unattended while the plasma power supply is on.
- XeF2 RULE, Do not leave plasma bay when XeF2 is in use on the XeF2 etcher.
- Users may not modify the equipment in anyway.

- Do not operate any equipment which is tagged with a DO NOT OPERATE sign or is placed in DOWN or MAINTENANCE in FOM.
- Safety is everyone's responsibility in the lab. All users are required to hold each other accountable for safe acts. If someone is working in an unsafe manner and you see them – you must tell them!

5.3 Chemical Safety

- Read SDS information prior to using a chemical or material you are not familiar with
- Do not mix solvents and acids at any time
- Do not store acids and bases together. Also be aware of storing incompatible chemicals together (one example is acetic acid and sulfuric acid react violently).
- Only chemicals currently in use may be outside of the chemical cabinet. Put your chemicals away when not in use.
- The metal wet benches are for solvents only. Solvents may only be heated in the metal wet benches.
- Metal chemical storage cabinets are for solvents only and are designated: FLAMMABLES
- White Polypropylene chemical storage cabinets are for acids and bases and are designated: CORROSIVES.
- The white polypropylene wet benches are for acids and bases only.
- When heating solvents on a hotplate, a user must be present, in front of the hotplate, watching it 100% of the time a beaker is physically on the hotplate.
- You must use additional personal protective equipment of face shields, aprons, and chemical gloves when handling corrosive/toxic chemicals and/or when working at a white corrosives wet bench. Aprons and face shields are provided at the wet benches.
- Only transport chemical bottles with bottle carrier or cart. When transporting corrosive/toxic chemical bottles a face shield, rubber apron, and chemical gloves must be worn.
- When transporting a chemical it must be in a closed labeled storage container. No moving chemicals in a beaker from bay to bay or bench to bench even.
- Do not touch anything outside of a wet bench with chemical gloves. This includes the wet bench's operational buttons. The only exception is chemical bottles.
- Before removing chemical gloves you are required to rinse them off using water first
- Only brand new unopened liquid chemicals that are approved on at least one tool in WCAM are allowed to be brought in by lab users (exceptions must be approved by a staff member and recorded in the exceptions database)
- Users are required to complete the material approval procedure, receive an approval email, and have it show up on the allowed materials list prior to a new material entering the lab. Users are responsible for providing all information needed for the new material to be approved for use.
- Chemicals in WCAM may never be taken out of the cleanroom lab, including personal chemicals and DI water. The only way they may leave is thru the proper disposal method in WCAM.

- All chemicals in WCAM must be disposed of properly. Solvents must be collected in the supplied solvent carboys. Acids and bases should be flushed down the acid/base drains in the corrosives bench used with plenty of water. There are exceptions to what corrosives can be put down the corrosives drains, so if the user is unsure they should check with a staff member. Chemicals that can definitely not go down the WCAM corrosives drains are: bromides, iodides, sulfides, and cyanides. These must be collected in proper waste containers and given to UW Environmental, Health, and Safety (EHS) department for proper disposal.
- All chemicals must have a Safety Data Sheet on file.
- All unattended chemicals in wet benches must be labeled with name, chemical, and date
- All chemicals must be stored in their original container or labeled second container. All secondary containers (exception is individual photoresist bottles) will have a completed ID label and HMIS label attached.
- Make sure the beaker material used for chemicals is compatible with the material. For example, do not use a glass or metal beaker for HF.
- No liquid chemicals (including water) may be stored in the dry boxes.
- No personal electronics are allowed in wet chemistry bay.
- Empty chemical containers should be placed on the chemical transportation cart provided in the Litho and Wet Chemistry bays.
- Do not use a wet bench when its exhaust alarm is ON.

For a more in depth explanation of WCAM's chemical hygiene policies see the WCAM document: WCAM Chemical Hygiene Policy Agreement. This document must be viewed and agreed to by a user prior to using the cleanroom lab.

5.4 Clean Room Lab Etiquette

- Everyone must be properly gowned at all times while in the clean room. For the proper gowning technique see ***Section 7.4 Donning Procedures***.
- Do not unzip your clean room suit to access items inside the suit.
- Users must take proper action to ensure they do not track water, snow, sand, salt, etc into the gowning room when they enter.
- Users may move personal items to and from the clean room. Items entering the clean room must pass thru the air shower and be wiped down prior to entering the clean room. Phones, cameras and laptops are allowed but must be wiped down as well.
- Users should not bring in particle producing materials such as: common paper, cardboard, wood, dry powders, fabric, etc.
- No liquids to be stored in the dry boxes.
- Do not smoke, chew gum, eat or drink in the lab at any time.
- No coats and backpacks in the lab.
- Follow the materials allowed list for each tool.
- Users are required to fill out the run log for each use of each tool. Do not falsify run logs.
- Leave your work area clean and store all chemicals, materials and equipment properly.

- Keep walkways and emergency exit doorways clear.
- Keep body and eye shower facilities clear in each bay.
- Do not log into a tool until you are ready to use it. No saving tools for yourself.
- WCAM staff reserves the right to disable access to a tool for a user or remove access to the cleanroom for improper or unsafe use
- Users shall not change or modify tools, control software, or computers in any way.

For a more in depth explanation of WCAM's lab rules and user responsibilities see the WCAM document: WCAM Rules Summary. This document must be viewed and agreed to by a user prior to using the cleanroom lab.

5.5 Training

- Lab users have to go thru a 3 step training process, including proper demonstration of safe use of the tool, to gain un-supervised access to the tool.
- Before training a user on a tool they must have a feasible reason to use the tool that will be discussed with the staff member doing the training.
- Standard Operating Procedures (SOP) for each tool can be found: by the tool, on WCAM's website, and in FOM.
- Proper training is done by the WCAM staff by appointment.
- FOM computer security system keeps track of equipment training status for individual lab users.
- Do not use equipment without logging into the equipment via the FOM system. Most systems have an interlock to prevent this from happening.
- Do not log into the FOM system for another person to use the equipment.

5.6 Micro/Nano Fabrication

- Only handle wafers or quartzware while wearing gloves and using tweezers.
- Ensure that the sample you are placing into each processing tool complies with the allowed materials list for that equipment.
- Users are responsible for leaving tools clean and in good operating condition like they found them.
- The photoresist coating hoods are to be used for lithography resist coating only.

5.7 Enforcement of Lab Rules and Policies

To ensure the safety and health of employees and users of the lab, adherence to all lab rules, policies, procedures and equipment operating instructions will be enforced. When an infraction occurs the laboratory staff is obligated to respond. Infractions are kept track of in the WCAM infraction database.

- Minor infractions – **email or verbal notice** to user indicating infraction and suggestion(s) for correction.
- Safety infractions (including but not limited to: lone worker rule, plasma rule, and all safety rules) – **suspended lab entrance** – email notice to user and advisor indicating infraction and length of suspension.
- Major Infractions or recurring infractions – **suspended lab entrance** – email notice to user and advisor indicating infraction and the determined suspension period. Before re-

entering the lab, the user may need to retest on lab safety procedures or specific safe tool operation.
- If the infraction is related to a specific tool the suspension may be specific to that tool, while allowing the user to still use the lab for other reasons.

Chemical Hygiene Plan
VI. Training

6.1 Lab User Training

6.1.1 New User Orientation

Each new employee or cleanroom lab user will be required to participate in lab safety orientation training. This training consists of on-line training topics with quizzes and a final on-site lab orientation which includes a cleanroom tour.

Prior to accessing the cleanroom lab a new lab user shall:

- Contact the chemical hygiene officer to obtain enrollment into the on-line training program.
- Inform the chemical hygiene officer when the on-line training program has been successfully completed.
- Setup an account on FOM with approved account numbers to pay for lab use.
- Attend an on-site cleanroom lab orientation and tour with the chemical hygiene officer.

The cleanroom lab orientation program contents are:

- On-line course
    - Chemical Safety and quiz
    - Fume Hood Safety and quiz
    - Fire Safety and quiz
    - Other Emergencies and Evacuation and quiz
    - Introduction to equipment available in WCAM and quiz
    - Explanation of WCAM Lab Policies and quiz
    - Presentation on the FOM access system for the lab and quiz
    - Video of gowning procedures
- On-site orientation
    - Entrance into lab gowning room and donning clean room suit
    - Demonstration of FOM computer access system
    - Walking tour of the cleanroom facility to identify locations of:
        - Emergency exit routes of the cleanroom and building
        - Location of eyewashes and body showers, including calcium gluconate gel for HF exposure
        - Right-To-Know area (SDS library and other safety info)
        - Fire extinguishers and emergency stations
        - EPOs
        - Lab supplies, chemicals, and proper storage areas
        - Emergency response cart and items in it

- Security cameras and bay safety screens

The objective of the quizzes is to reinforce basic safety principles which apply to the cleanroom. Users are able to view the on-line topic presentations and take the quizzes as often as necessary to achieve an 80% score.

After the completion of the online safety course and on-site lab orientation the user will need to complete the College of Engineering building access requirements in order to be able to access the cleanroom lab facility. The cleanroom entrance is kept locked from the outside and can only be unlocked by using a UW RFID card that has been authorized by the College of Engineering building access software.

6.1.2 Annual Renewal Safety Training
Each year on the anniversary month of safety orientation, a user is required to attend a renewal session. The session will cover the following discussion topics:

- Review of lab rules and safety
- Changes in cleanroom policy
- Problems or situations occurring in the cleanroom that need correction
- User suggestions for improvements in the cleanroom
- A presentation by the Environment Health & Safety office from the UW

6.1.3 Equipment Training
Use of any equipment, machine, or device without prior staff training is prohibited. This is for the protection of the user. WCAM staff will train the user in the correct and safe way of operating any machine or equipment within the lab facility. Remember: Some processes take considerable time to complete. **The user will need to coordinate training time with staff in advance of the process.**

6.2 Lab Employee Training

All employees will complete the same training as new lab users. Additional training for employees include, but not exclusively:

- Lock out/tag out procedures
- SCBA training
- CPR/AED training
- First aid training

The chemical hygiene officer will maintain training and test records.

6.3 Additional Information Available

6.3.1 Computer Access
Computers will be located throughout the lab for employees and users to access. The computers will be available for scheduling of equipment, logging into equipment use, and internet and email access.

6.3.2 Right-To-Know Area

An area in the gowning room will be designated the Right-To-Know Area. The area will include the following:

- The Occupational Safety and Health Administration (OSHA) Standards
- The Emergency Response Guidebook
- The Chemical Safety and Disposal Guide by the UW Safety Department
- The Safety and Health Program of Wisconsin Center for Applied Microelectronics
- GHS SDS for every chemical used in the cleanroom

6.4 Notification to End User Status

WCAM is a cost recovery facility. The charge to an advisor is based on a monthly user access, attendance in the lab and use of equipment. **It is the responsibility of the user and/or the advisor to notify the lab facility of a change in user status.**

Chemical Hygiene Plan

VII. General Laboratory Guidelines and Protocols

7.1 Good housekeeping in lab

A clean workplace is a safe workplace. When your work area has only the chemicals and glassware you need, the chance of spills is reduced and you will be able to identify any potential hazards such as incompatible chemicals.

A clean workplace will save you time. When glassware, chemicals, and personal protective equipment are stored properly you can easily locate needed items.

7.2 Lone Worker Rule

Since the WCAM lab has many processes requiring hazardous materials, all lab users are to be within sight and hearing of another user at all times. Security cameras and monitors in each cleanroom bay showing a live feed of every other bay have been installed to help with this. This rule is especially important to follow when working during evenings and weekends when staff is not present. Between 5:00 PM and 7:00 AM Monday through Thursday and weekends from Friday at 5:00 PM until 7:00 AM Monday, there must be two or more lab users present in the cleanroom.

Lab users have the following responsibilities:

- After normal work hours you must enter and exit with another cleanroom user if no other users are present in the cleanroom.
- During normal work hours as 5:00 PM approaches, you need to identify other users in the cleanroom that will be staying after 5:00 PM and coordinate your exit from the cleanroom with other users present so that no one is ever alone in the cleanroom after hours.
- After normal work hours, you must not leave a lone worker in the WCAM cleanroom. When you are exiting after 5:00 PM, the FOM system will alert you if a single person is still present in the cleanroom. You must coordinate your FOM exit from the cleanroom with the last person in the lab.

7.3 Clothing, Gloves and Personal Protective Equipment

7.3.1 Shoes

In any part of the WCAM lab, you are to wear proper lab footwear. Sandals and open-toed shoes are prohibited. Your shoes must have a closed toe with the top of the foot covered.

7.3.2 Gloves

There are two types of gloves available in the lab. The always required disposable nitrile gloves are to prevent user contamination of the cleanroom. They do not provide adequate protection against many chemicals. Chemical gloves must be worn, along with other personal protective equipment, when doing any processes involving corrosive chemicals. The chemical gloves are worn over the top of the cleanroom nitrile gloves.

You should inspect the chemical gloves you are wearing often for holes or tears. Rinse the gloves frequently during use and discard them if they show any signs of wear or damage. Also, it is good practice to wash your hands when you leave the cleanroom. Some chemicals may absorb thru the nitrile gloves when not required to wear chemical gloves or you may come in contact with a chemical while removing the gloves.

7.3.3 Wearing PPE

WCAM provides the appropriate protective equipment such as safety glasses, goggles, face shields, nitrile clean room gloves, chemical gloves, and chemical aprons. These items are located throughout the lab. If any equipment is damaged or worn, the safety equipment must be replaced prior to use.

For eye protection, safety glasses are to be worn at all times while working in the lab. The only exception to this rule is while looking thru a microscope. Wearing contact lenses is not recommended for laboratory work. The safety glasses/goggles will be located in the gowning room and are part of the gowning procedures. Regular eyeglasses are not safety glasses. Exception: If a user can show proof of safety eyewear with side shields, he may forego the use of the provided lab safety glasses.

7.3.4 Respirator Use

Users of the cleanroom have no reason to use respirators and the use of them is solely for cleanroom staff for maintenance procedures, repairs, and emergency situations. For full face respirator use for SCBA use see section 7 of 4.1.1. For half mask respirator use cleanroom staff will follow the manufacturer instructions and will make sure the cartridges used are appropriate for the task that the half mask respirator is being used.

7.4 Donning Procedures

7.4.1 Cleanroom Suits (Bunny Suits)

The bunny suits are located at the lab entrance. The bunny suit is to be worn only within the cleanroom. While wearing a bunny suit, keep it fully zipped and snapped with the hood tucked inside the suit. The boots should be securely fastened on your feet. Do not unzip the suit while in the cleanroom to access things like pens and cell phones; make them available to yourself when you don the suit.

It is important to note that the bunny suits provide only incidental protection from chemical splashes. The bunny suits are designed to keep the cleanroom environment free from contamination and are not considered personal protective equipment for hazardous chemicals. Proper equipment such as face shields and corrosive resistant garments must be worn during hazardous chemical use.

7.4.2 Donning Cleanroom Suits

Step 1	Clean street shoes in shoe cleaner located at hallway entrance
Step 2	Step on tacky mat to remove debris
Step 3	Use proximity access card to enter gowning room and step on second tacky mat
Step 4	Clean incoming materials in materials air shower. See ***Section 7.5 Incoming Materials To The Cleanroom***
Step 5	Don hair bouffant
Step 6	Pick up two shoe covers
Step 7	Sit on "Street Clothes" bench
Step 8	Slip on one shoe cover over each shoe
Step 9	Wash and dry hands
Step 10	Don gloves
Step 11	Pick up hood and suit
Step 12	Don hood first
Step 13	Step into suit with little or no touching of floor.
Step 14	Check mirror for suit arrangement and nametag visibility.
Step 15	Pick up booties from size bin
Step 16	Sit on "Clean Room Suits Only" bench
Step 17	Slip on one bootie over shoe and swing leg over bench to "clean" side of gowning room
Step 18	Repeat with other foot
Step 19	Pick up and don supplied safety glasses or goggles
Step 20	On "clean" side pick up personal materials from material air shower or your white storage bin
Step 21	Log into cleanroom computer system
Step 22	Enter clean room

7.5 Incoming Materials into the Cleanroom

This procedure is for materials coming into the cleanroom that have **not** been double wrapped in a cleanroom by the vendor. Users must follow this procedure each time materials such as wafer boxes or supplies are being transferred into the cleanroom.

- Enter the gowning room and place your material into the air shower.
- Wipe down the exterior of the material. 70% DI water/30% IPA squirt bottle and Texwipes are supplied by the air shower for this reason.
- Leave the items in the air shower, complete the gowning procedure and pick up the items prior to entering the cleanroom via the FOM system. See ***Section 7.4 Donning Cleanroom Suits***.

7.6 Cleanroom Exiting

Users are responsible for leaving the workspace clean and properly storing lab materials, chemicals and personal items prior to exiting the clean room. No items should be left in the workspace. The lab user is to follow the proper exit procedure:

Step 1	Logout of cleanroom FOM system via the exit computer
Step 2	Exit to cleanroom gowning area
Step 3	Remove and store safety glasses/goggles
Step 4	Store personal materials in storage bin
Step 5	Sit on "Cleanroom Suits Only" bench and remove one bootie and swing leg over bench then repeat for second bootie
Step 6	Store booties in the bootie bins by size
Step 7	Remove and hang suit and hood
Step 8	Place hair bouffant and shoe covers in personal cubby supplied for this and reuse until new ones are needed
Step 9	Throw away nitrile gloves
Step 10	Exit gowning room

Chemical Hygiene Plan

VIII. Hazard Awareness and Response

8.1 Hazard Exposure

8.1.1 Detection of Hazards

There are several methods an employee or user can detect the presence of a hazardous substance.

- Visual – The employee and user should assume a hazard is present when a liquid is observed on a workstation surface or the floor. Take all precautions of a chemical spill and assume the liquid is toxic. Follow ***Section 8.2.1 Chemical Spill Clean Up Procedures***.
- Smell – Some chemicals and gases will emit an odor. Employees and users should evacuate to fresh air and report the incident to lab management.
- Symptoms – Some chemicals and gases do not emit an odor but a person can experience symptoms such as dizziness, fatigue, headaches, skin rashes or sudden change in personality. Employees and users should evacuate to fresh air and report the incident to lab management.

8.1.2 Response to Exposure

When an employee or user has been exposed to chemicals immediate steps should be taken:

- Eyes and face – Hold open eyes and lean over eyewash. Operate the eyewash for 15 minutes. Seek medical help.
- Body – Stand under an emergency show and pull the handle. Remove contaminated clothing and flush affected area for 15 minutes. A blanket, robes, and socks are available on the emergency response cart to aid the person after using the safety shower. Seek medical help.

- In the case of hydrofluoric acid (HF) exposure, after rinsing with water for 5 minutes start applying calcium gluconate gel. The gel is located in any chemical work area with HF attached to the emergency shower. Call 911 or go to emergency room immediately.
- Someone nearby should be assisting the person and/or calling **911** for medical assistance. Two telephones are located in the main clean room corridor.

For a full in depth explanation of these procedures, see the documents:
WCAM-002.R1 Chemical Splash to the Eye Response
WCAM-003.R1 Corrosive Chemical Splash to the Skin Response
WCAM-007.R1 Hydrofluoric Acid Splash to the Skin Response
WCAM-008.R1 Non-corrosive Chemical Splash to the Skin Response

8.2 Chemical Spill Clean-up Procedures

8.2.1 General Clean-up Procedures

The following are the basic procedures for handling a chemical spill clean-up. At all times you should be familiar with procedures specific to a chemical or gas. In the event of an extremely dangerous situation, after evacuation call **911**.

- Remove all unnecessary people from the exposure area and put up notification to not enter the area
- Wear personal protective equipment such as face shield, apron and chemical gloves
- Understand what chemical you are dealing with and its hazards. If the liquid is unknown assume it is the worst possible chemical in the lab. Chemical identification strips are available in the emergency response cart.
- Control or stop the spill or leak as soon as possible. Use a chemical boom to surround the spill, spray the spill with the appropriate neutralizer, and carefully place spill pillows on top of the spill.
- Spill pillows and booms are available on the Emergency Response Cart and in every room with chemicals.
- If the chemical is flammable remove or control all ignition sources, such as a hotplate.
- For a large spill or extremely hazardous chemical the lab should be completely evacuated and 911 should be called
- Notify WCAM cleanroom staff of all spills immediately after the situation is under control. The spill will be evaluated by the staff for the appropriate emergency response action.
- Only trained persons with proper personal protective equipment should address the spill emergency

For a more in depth explanation of chemical spill response procedures in WCAM, see the document:
WCAM-001.R1 Chemical Spill Response

8.2.2 Mercury Spill Clean-up Procedures

WCAM promotes the policy to eliminate the use of mercury thermometers. The UW Safety Dept. offers a program to exchange mercury thermometers for environmentally safe thermometers. WCAM does not allow the use of mercury in the cleanroom and does not allow thermometers with mercury in them to be in the lab. WCAM still does keep a mercury spill kit on the emergency response cart. In the event it is needed the manufacturer instructions, in the kit, should be followed to clean-up the mercury spill.

8.3 Chemical Waste Disposal

- Wear personal protective equipment: face shield, rubber apron, and chemical gloves
- Wipes contaminated with corrosives should be thoroughly rinsed and placed in the corrosives waste receptacle (white trash cans)
- Wipes used with solvents should be placed into the waste receptacle labeled for solvents (metal trash cans)
- Solvent waste such as acetone, isopropanol, etc., should be dispensed into the round waste carboys located in the solvent waste cart
- Acid and base chemical waste is disposed of by the dilution method down the lab's corrosives drains located in the corrosive wet benches. Place beaker containing the chemical in the sink. Start a cascade of water into the beaker. Continue water flow for 10-15 minutes.
- Not all corrosives can be put down the lab's corrosives drains. Chemicals that must be collected as waste and given to the UW safety department for proper disposal include but are not limited to: sulfides, cyanides, bromides, and iodides
- Empty chemical bottles are to be rinsed using the bottle wash in room 3027 and then placed in the trash. Student hourlies will do this. Users of the lab just put empty chemical bottles in the empty bottle cart.
- Caution: Care must be taken when disposing of sulfuric acid, H_2SO_4, as it reacts violently with water. Start the dilution process with a very low water flow, and then slowly increase the water flow into the beaker.

8.4 Sharps Disposal

Sharps may be disposed of in the red containers in each cleanroom bay. The containers are labeled: Sharps Disposal. The clean room staff will collect the sharps; seal them in a labeled container and dispose of them via university policies.

8.5 Toxic Gas Alarm

When the gas monitoring system detects a leak of a toxic compressed gas, toxic gas alarms will automatically be activated. See ***Section 4.1.1 Compressed Gas Handling Protocol***. The audible and blue strobe light alarms are located in all cleanroom bays and in the hallways adjacent to the cleanroom. Employees and lab users should immediately follow the evacuation procedures. See ***Section 8.7 Evacuation Procedures***. In the event of a toxic gas alarm, all lab occupants are to evacuate the lab and building immediately. The responding staff will assess the emergency, dial 911 to report any injury, and consult the SDS sheets for first aid treatment. Trained staff will act as incident consultants to responding emergency response teams such as UW Police Department, Madison Fire Department and/or Praxair LEAP team. See the following document for an in depth explanation of WCAM's Toxic Gas Alarm system and response procedures: WCAM-011.R1 TGM Evacuation & Response.

8.6 Fire Safety

8.6.1 Fire Prevention

Identifying fire hazards is the first step toward fire prevention. Employees and lab users should help prevent fires by following some easy guidelines:

- Keep work areas clean
- Store flammable and combustible materials properly

- Never leave an ignition source, like a hotplate, unattended
- Never leave a flammable on a hotplate unattended
- Keep walkways and exits clear
- Know where fire alarms, fire extinguishers and telephones are located and the evacuation routes
- Complete the on-line training for fire safety. See ***Section 6.1 Lab User Training***.

8.6.2 General Rules for Fire Safety

Fire is a possibility in any workplace setting. Response in a fire emergency is critical. Users should follow these rules:

- If there is a fire and the fire alarms have not gone off by themselves yet, pull a fire alarm pull. Fire alarm pulls are located in each utility chase and at the end of the cleanroom corridor. Additional fire alarm pulls are located at the building stairway exits.
- The audible and white strobe light fire alarms are located throughout the building
- If there is smoke stay low to the ground
- Touch doors to see if they are hot before opening them
- Use emergency exits and know the evacuation routes for the building
- If the fire is manageable, you can try to use a fire extinguisher
- Once safely out of the building call **911** to give further details of the fire incident. When you call 911 be prepared to:
    - Identify yourself and the reason you are calling
    - Identify the exact location of the emergency
    - Identify the nature of the emergency
    - Identify any injuries or symptoms involved
    - Identify all hazardous materials involved that you are aware of
    - Stay on the phone until the dispatcher tells you it is okay to hang up

8.6.3 Fire Extinguishers

Fire extinguishers are located in the main corridor of the cleanroom, on the solvent carboy carts, the maintenance repair area, and building hallways. All employees and users will complete on-line training on fire safety. See ***Section 6.1.1 New User Orientation***. The key to fire extinguisher use is to keep a safe exit behind you in case the fire gets out of hand and remember **PASS**:

- **P** – Pull the pin on the fire extinguisher
- **A** – Aim the nozzle at base of fire from 8-10 feet away
- **S** – Squeeze the handle.
- **S** – Sweep back and forth at the base of the fire while advancing towards it as it goes out

For a more in depth procedure on fire response, see the document: WCAM-006.R1 Fire Emergency Response.

8.7 Evacuation Procedures

When a fire alarm or the toxic gas monitor alarm has been triggered, the UW Police and Madison Fire Department are automatically notified through the building systems. Upon hearing or

seeing an alarm, employees and users must immediately evacuate the building using these guidelines:

- Stay calm
- Leave the cleanroom via the nearest emergency exit with your cleanroom suit still on. Undo the suit at a safe location.
- Turn off any equipment and close any doors as you leave, if there is time
- Do not use elevators
- Only use stairways
- Follow the evacuation route signs and arrows unless smoke and/or fire are present on these routes
- If a stairway contains smoke or flames use an alternative stairway exit
- Assemble at the evacuation meeting area on the north side of the building by the church
- Do not re-enter the building until the "all clear" has been given by the fire department

For a more in depth procedure on WCAM's evacuation procedure, see the documents: WCAM-004.R1 Emergency Evacuation Response & WCAM-005.R1 Evacuation Map & Important Phone Numbers.

8.8 Tornadoes or Severe Weather

Wisconsin is in an area that can experience tornados or severe weather anytime from April to October. The majority of the tornados occur in the early summer months with the most severe occurring in April and May.

8.8.1 Tornado Watch and Tornado Warning Alerts

A **tornado watch** means weather conditions are favorable for the development of tornadoes in the area. You should be aware of the conditions and be prepared to move to a safe location.

A **tornado warning** means a tornado has been sighted in the area. The U.S. Weather Bureau will issue a warning for the area and the Dane County Emergency System will be activated. Leave the cleanroom and move immediately to a safe location.

WCAM has a weather alert system hooked into the cleanroom PA system. When there is a tornado or severe thunderstorm warning the weather alert system will notify lab occupants via the PA system.

8.8.2 Emergency Procedures

You should find immediate shelter when emergency sirens and warnings on the radios and televisions indicate a tornado warning. Safe shelter would be an interior hallway, lower floor or basement. You should stay away from outside walls, glass windows or partitions. Face the wall and cover your head with your hands. Do not leave the safe shelter until a siren or media has broadcasted an all-clear announcement.

See the following document for the full severe weather response plan in WCAM: WCAM-009.R1 Severe Weather Response.

IX. Medical Consultation and Examination

9.1 General

This laboratory provides laboratory personnel and users working with hazardous chemicals an opportunity to receive medical attention, if necessary. University laboratory personnel may receive medical care through their chosen health care plan under the State Group Health Insurance Program. Students may receive medical care from the University Health Services (UHS) department. For more information or guidance, contact the Safety Department's Occupational Health Manager.

9.2 Required Medical Exams for Respirator Use

Any employee required to wear either a half-face respirator or self-contained breathing apparatus (SCBA) to perform equipment maintenance or respond to an emergency situation will need yearly medical clearance from UHS. This entails filling out a medical questionnaire that will be reviewed by a UHS doctor. See ***Section 4.3.4 Mandatory Respirator Use***.

The chemical hygiene officer will maintain all records in employee training files.

X. Reference Sources

American industrial Hygiene Association: *Laboratory Chemical Hygiene — An AIHA Protocol Guide*. Fairfax, VA: American Industrial Hygiene Association, 1995.

Applied Energy Systems: *2 Cylinder Semi-Auto Gas Cabinet Operations and Owners Manual*. Malvern, PA, 2001.

Compressed Gas Association, Inc.: *Handbook of Compressed Gases, 4th Edition*. Norwell, MA: Kluwer Academic Publishers, 1999.

Compressed Gas Association, Inc.: *Safe Handling of Compressed Gases in Containers*. Arlington, VA: Compressed Gas Association, Inc., 2000.

Furr, A. Keith: *Handbook of Laboratory Safety*. Boca Raton, FL.: CRC Press, 1990.

Mercier, Paul: *Laboratory Safety Pocket Handbook*. Schenectady, NY: Genium Publishing Corporation, 1996.

National Research Council: *Prudent Practices in the Laboratory — Handling and Disposal of Chemicals*. Washington, D.C.: National Academy Press, Third Printing, 2000.

Semiconductor Equipment and Materials International: *Facility Standards and Safety Guidelines*. Mountain View, CA: SEMI, 1999.

U.S. Department of Labor, Occupational Safety & Health Administration: *Regulation Standards 29 CFR — General Industry 1910.* Washington, D.C.: Occupational Safety & Health Administration.

U.S. Department of Labor, Occupational Safety & Health Administration: *Regulation Standards 29 CFR — Occupational Exposure to Hazardous Chemicals in Laboratories 1910.1450*. Washington, D.C.: Occupational Safety & Health Administration.

University of Wisconsin Safety Department: *Chemical and Environmental Safety Program and General Safety Program*. Madison, WI.

Wisconsin State Statute 101: *Wisconsin Administrative Code, Department of Commerce, Chapter 32, Public Employee Safety and Health*. Madison, WI.

Zellweger Analytics, Inc.: *CM4 Four-Point Continuous Monitor Technical Handbook*. Lincolnshire, IL, 1998.

XI. Appendices

The following appendices contain portions of technical manuals that relate directly to compressed gas handling protocols.

A. Gas Cabinets

Applied Energy Systems, Inc.
Cylinder Semi-Auto Gas Cabinet
Operations and Owners Manual, November 2001
Section 5.3.10, Cylinder Change with an Emergency Shutdown Option, pp. 20-21.

Appendix A.
Applied Energy Systems, Inc.
Cylinder Semi-Auto Gas Cabinet
Operations and Owner's Manual, November 2001

5.3.10. Cylinder Change with an Emergency Shutdown System option.

When the high pressure gauge on the regulator drops to 10% of new cylinder pressure, a cylinder change is recommended. Using the following procedure, purge of the high pressure side only is required, thus conserving on process gas.

1. Turn the key switch on the ESS to "Purge"
2. Close the High Pressure Isolation Valve (B).
3. Close the Cylinder Valve (A).
4. Open the Vacuum Assist Valve (r).
5. Open the High Pressure Vent Valve (q).
6. Close the High Pressure Vent Valve (q).
7. Open the Purge Gas Inlet Valve (p).
8. Close the Purge Gas Inlet Valve (p).
9. Open *the High Pressure Vent Valve* (q).
10. Close the High Pressure vent Valve (q).
11. Repeat steps 6 through 9 at least 20 times.
12. Close Emergency Shutoff Valve (E) using ABORT.
13. Press Alarm Silence switch to deactivate buzzer.
14. Close the cabinet window and open door.
15. Remove spent cylinder; use gloves and face protection.
16. Install new cylinder. Review section: instruction on **"Safe Cylinder Installation"** for proper procedures. ***Do not yet open cylinder valve*.**
17. Close cabinet door and open window.

18. Open Emergency Shutoff Valve (E) using RESET.
19. Open the Purge Gas Inlet Valve (p).
20. Close the Purge Gas Inlet Valve (p).
21. Open the High Pressure Vent Valve (q).
22. Close the High Pressure Vent Valve (q).
23. Repeat steps 14 through 18 at least 20 times.
24. Close the vacuum Assist Valve (A).,
25. Slowly open the Cylinder Valve (A).
26. Slowly open the High Pressure Isolation Valve (B).
27. Close the cabinet window.

Index