Specification
for

Semiconductor, Laboratory, and Facility Equipment and Support Equipment (e.g., Chemical, Gas, Waste, Pollution Control)

REVISION

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1. PURPOSE AND SCOPE

1.1 The purpose of this document is to establish the minimum requirements / specifications for equipment being installed at the Albany NanoTech Complex (ANC) (Site) and the AIM Photonics, Test, Assembly, and Packaging Facility (TAP) (Site) in Rochester, NY.

1.2 Such equipment shall include but is not limited to: Semiconductor Tooling, Laboratory Equipment, and Facilities Equipment, Ozone (O_3) Gas Generators, Gas Cabinets (GC), Valve Manifold Boxes (VMBs), T-Boxes, Gas Interface Boxes (GIBs), Chemical Dispense Units (CDU), Waste Collection Units, Chemical Storage Cabinets and Abatement Devices. The equipment must meet relevant regulatory and industry standard requirements.

1.3 The requirements for local exhaust ventilation systems are not covered by this procedure but are covered in **EHS-00053** - **Local Exhaust Ventilation Requirements**.

2. DEFINITIONS

2.1 **Chemical Dispense Units (CDU)**: A fully enclosed, noncombustible enclosure used to provide an isolated environment for liquid chemicals in storage or in use.

2.2 **Chemical Storage Cabinets**: Polyethylene or metal-coated polyethylene cabinets used to store and contain flammable, corrosive acid, or corrosive-based materials.

2.3 **Excess Flow Control**: A flow switch or similar excess flow measuring device installed with a shut off valve in the distribution system of a compressed gas cylinder, portable tank, or stationary tank that is designed to positively shut off the flow of gas or liquid in the event that its predetermined flow is exceeded.

2.4 **Exhausted Enclosure**: An appliance or piece of equipment that consists of a top, a back and two sides providing a means of local exhaust for capturing gases, fumes, vapors, and mists. Such enclosures include laboratory hoods, exhaust fume hoods, tool gas boxes, Gas Interface Boxes (GIBs), precursor boxes, and similar appliances and equipment used to locally retain and exhaust the gases, fumes, vapors, and mists that could be released. Rooms or areas provided with general ventilation, in themselves, are not exhausted enclosures.

2.5 **Gas Cabinets (GC)**: A fully enclosed, noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage or use. Doors and access ports for exchanging cylinders and accessing pressure-regulating controls are allowed to be included.

2.6 **Gas Interface Box (GIB) or Tool Gas Box**: A gas system enclosed in a cabinet typically adjacent to the process tool or onboard the tool. It is the final gas system prior to the process chamber. The gas system is similar to a VMB and VMP.

2.7 **Hazardous Production Material (HPM)**: A solid, liquid, or gas associated with semiconductor manufacturing that has a hazard rating in health, flammability, or reactivity of Class 3 or 4 as ranked by NFPA 704 and which is used directly in research, laboratory, or production processes that have as their end product materials that are not hazardous.

2.8 **Inboard Leak:** A leak from outside to inside the tested system, when the external partial pressure surrounding the system is greater than the internal partial pressure.

2.9 **Internal Leak**: A leak occurring across a flow barrier of a component of the tested system, such as the seat of a closed valve.

2.10 **Leak**: Path(s) in a sealed system that will allow material to pass through it when a partial pressure differential exists. There are two typical mechanisms for such a leak:

- A mechanical passage or
- A porous material through which material can diffuse or permeate.

2.11 **Measured Leak Rate**: The quantity of helium at the recorded testing conditions of temperature and pressure flowing through a leak. *Measured Leak Rates* should be converted to *Standard Leak Rates* via the following equation prior to comparison with the site requirements set out in this document.

Stand Leak Rate = *Measured Leak Rate * Pressure Correction * Temperature Correction*

- *Pressure Correction* = (101.3 kPa) / (Actual He Absolute Pressure)
- *Temperature Correction* = (Actual Absolute Temperature) / (295 °K)

2.12 **Ozone (O_3) Gas Generator**: Equipment which causes the production of O_3.

2.13 **Outboard Leak**: A leak from inside to outside the tested system, when the internal partial pressure is greater than the external partial pressure surrounding the system.

2.14 **Pyrophoric Materials**: Materials that have an auto-ignition temperature of ≤130 °F.

2.15 **Restricted Flow Orifices (RFO)**: Orifice placed in a fitting or pipe to restrict the amount of flow that can go through the pipe or fitting.

2.16 **Reduced Flow Valve**: A valve equipped with RFO and inserted into a compressed gas cylinder, portable tank, or stationary tank that is designed to reduce the maximum flow from the valve under full-flow conditions. The maximum flow rate from the valve is determined with the valve allowed to flow to atmosphere with no other piping or fittings attached.

2.17 **Splitter/T-Boxes**: Break in liquid double contained line where connections and valves are housed.

2.18 **Standard Leak Rate:** The quantity of helium at 295 K (22 °C) and 101.3 kPa (1 atm) flowing through a leak when the partial pressure of helium on the high-pressure side is 101.3 kPa and the partial pressure on the low-pressure side is much lower.

2.19 **Valve Manifold Boxes (VMB)**: A box connected to the piping GC or large-flow special gas distribution panel. The gases are distributed to the equipment of need after pressure and flow regulation. VMB is a device that distributes specialty gases safely and stably to semiconductor production equipment. VMBs are considered exhausted enclosures.

2.20 **VESDA:** Very Early Smoke Detection Apparatus

Workstation: A defined space or an independent principal piece of equipment using HPM within a fabrication area, where a specific function, laboratory procedure, or research activity occurs. Approved or listed hazardous materials storage cabinets, flammable liquid storage cabinets, or GC serving a workstation are included as part of the workstation. A workstation is allowed to contain ventilation equipment, fire protection devices, detection devices, electrical devices, and other processing and scientific equipment.

3. RESPONSIBILITIES

3.1 **Environmental Health and Safety (EHS)** is responsible for program development, advice, and counselling to management and employees, professors, students, tenants, contractors, and vendor employees.

3.2 **All users on site** are responsible for following the requirements in this program.

3.3 **Designers, Installation Contractors, Installation Engineers, Equipment Engineers, Supervisors, Managers, and Professors** are responsible for the implementation and oversight of this program.

4. SYSTEMS, EQUIPMENT, AND PROCESSES IN CONTROL AREAS

4.1 The storage, use, and handling of hazardous materials in amounts not exceeding the maximum allowable quantity per control area (2020 NYS Fire Code Table 2704.2.2.1) shall comply with the following:

- Containers, cylinders, and tanks shall be designed and constructed in accordance with approved standards. Containers, cylinders, tanks, and other means used for containment of hazardous materials shall be of an approved type.
- Piping, tubing, valves, and fittings conveying hazardous materials shall be designed and installed in accordance with Table 2 - Process Gas Installation Reference.
- Piping, tubing, valves, fittings, and related components used for hazardous materials shall be in accordance with the following:
  - Piping, tubing, valves, fittings, and related components shall be designed and fabricated from materials compatible with the material to be contained and shall be of adequate strength and durability to withstand the pressure, structural and seismic stress, and exposure to which they are subject.
  - Piping and tubing shall be properly labeled per site requirements.
  - Readily accessible manual valves; or automatic, remotely-activated, fail safe emergency shutoff valves shall be installed on supply piping and tubing at the point of use and at the tank, cylinder, or bulk source.

4.2 Emergency shutoff valves shall be identified; the location shall be clearly visible, accessible, and indicated by means of a sign.

4.3 Backflow prevention or check valves shall be provided when the backflow of hazardous materials could create a hazardous condition or cause the unauthorized discharge of hazardous materials.

4.4 P-Traps are required for both sink and hood drains.

- They are not required to be wetted with UPW or city water.
- If the tool / equipment has a settling tank that effectively acts like a P-Trap, a P-Trap is not required.
- The trap must be “wetted” if it is normally dry (e.g., tool pan drain, floor drain) where vapors from the wastewater that they are connected to may migrate into the tool/room.
- A P-Trap shall not be larger than the waste pipe to which it is connected.
- P-Traps must be constructed of adequately listed material for their intended use.

4.5 Where gases or liquids having a hazard ranking of Health Hazard Class 3 or 4, Flammability Class 4, or Reactivity Class 3 or 4:

- In accordance with NFPA 704, for gases and liquids that are carried in pressurized piping above 15 psig (103 kPa), an approved means of leak detection and emergency shutoff or excess flow control shall be provided.
- Where the piping originates from within a hazardous material storage room or area, the excess flow control shall be located within the storage room or area.
- Where the piping originates from a bulk source, the excess flow control shall be located as close to the bulk source as practical.
- Supply piping and tubing for gases and liquids having a health-hazard ranking of 3 or 4 shall have welded connections throughout except for connections located within an exhausted enclosure if the material is a gas, or an approved method of drainage or containment is provided for connections if the material is a liquid and shall not be located within corridors, within any portion of a means of egress required to be enclosed in fire-resistance-rated construction, or in concealed or confined spaces in areas not classified as Group H Occupancies.

5. HAZARDOUS MATERIALS STORAGE CABINETS

5.1 Construction

- The interior of cabinets shall be treated, coated, or constructed of materials that are not reactive with the hazardous material stored. Such treatment, coating, or construction shall include the entire interior of the cabinet.

- Cabinets shall either be listed in accordance with UL1275 as suitable for the intended storage or constructed in accordance with the following:

- Cabinets shall be of steel having a thickness of not less than 0.0478 inch (1.2 mm, 18 gauge).
- The cabinet, including the door, shall be double walled with 1.5-inch (38 mm) airspace between the walls.
- Joints shall be riveted or welded and shall be tight fitting.
- Doors shall be well-fitted, self-closing, and equipped with a self-latching device.
- The bottoms of cabinets utilized for the storage of liquids shall be liquid tight to a minimum height of 2 inches, or 10% of the volume of the largest container.

5.2 Labeling

- Cabinets shall be provided with a conspicuous label in red letters on contrasting background which reads: HAZARDOUS - KEEP FIRE AWAY.

6. GAS CABINETS (GC), AND EXHAUSTED OR VENTILATED ENCLOSURES

The following requirements shall apply to GCs, VMBs, purifier cabinets GIBs, exhausted enclosures, and/or ventilated enclosures used for storing or otherwise containing gases with an NFPA rating of a 3 or a 4 for health or reactivity or 4 for flammability, unless otherwise noted.

6.1 Cabinets must have leak detection and/or an excess flow switch that, upon detection, are interlocked to shut off flow of gas and send an alarm back to the Area Alarm Controller (AAC).

6.2 For Vacuum Pump Enclosures (*SEMI S6 R3-6.1.6 and SEMI S6 R3-6.1.6.1*): when toxic or highly toxic gases are used in the process or generated as byproducts, additional ventilated enclosures are required to manage the pumps and effluent connections adequately. Pump effluent connections shall be contained within a ventilated enclosure and monitored for gas leaks (*SEMI S2*).

6.3 Cabinets must have exhaust flow/pressure switches that are interlocked to shut off flow and send an alarm back to the AAC.

6.4 Cabinets must be equipped with an Emergency Machine Off (EMO) button that is hardwired to the respective unit and has the ability to send a signal to the AAC.

6.5 Heat detection shall be provided in cabinets that use flammable gases. Heat detectors shall be mounted on the exhaust duct and set to 120 °F. Flame detection will be in the form of snap switches and must be wired back to the AAC for monitoring.

- Per NFPA 318, UVIR or dual IR detectors or a VESDA may be installed in cabinets that house pyrophoric materials.

6.6 ANSI/CGA-13 and NYS fire code require the maximum volumetric flow rate of air shall for exhausted enclosures not be less than the standard silane volumetric flow rate multiplied by 250.

Table 6—Minimum ventilation volumetric flow rate for gas cabinets and valve manifold boxes—unattended operations

Source pressure (psi)	Typical gas cabinet RFO 0.006 in (0.15 mm) diameter		Typical gas cabinet RFO 0.010 in (0.25 mm) diameter		Typical VMB RFO 0.014 in (0.36 mm) diameter		Typical VMB RFO 0.020 in (0.51 mm) diameter	
	Silane flow (scfm)	Ventilation flow (scfm)	Silane flow (scfm)	Ventilation flow (scfm)	Silane flow (scfm)	Ventilation flow (scfm)	Silane flow (scfm)	Ventilation flow (scfm)
50	0.025	6	0.069	17	0.136	34	0.288	72
100	0.045	11	0.124	31	0.243	61	0.497	124
200	0.085	21	0.237	59	0.465	116	0.949	237
400	0.173	43	0.480	120	—	—	—	—
600	0.275	69	0.755	189	—	—	—	—
800	0.395	99	1.08	270	—	—	—	—
1000	0.555	139	1.51	378	—	—	—	—
1200	0.724	181	1.97	493	—	—	—	—
1500	0.913	228	2.50	625	—	—	—	—
1650	0.987	247	2.70	675	—	—	—	—

NOTES

1 Silane source temperature is 75 °F (24 °C).

2 RFO downstream pressure is 0 psi.

3 RFO discharge coefficient is 0.8.

4 To convert standard cubic feet per minute (scfm) to standard liters per minute (slpm), multiply by 28.32.

5 To convert psi to kPa, multiply by 6.895.

6.7 The following chart lists the GC and VMB types installed on site with their associated flow requirements:

TYPE	FLOW REQUIREMENT (Non-Pyrophoric) cubic feet minute (cfm)	FLOW REQUIREMENT (Pyrophoric) cubic feet minute (cfm)
PFT and CERES Nanopurge A21/A212/P21/P212 GC	89 cfm	590 cfm
PFT and CERES Nanopurge A14/A18/P14/P18 VMB	130 cfm	440 cfm
Original style PFT two-cylinder GC	220 cfm	275 cfm
Original style PFT three-cylinder GC	275 cfm	--
Original style PFT VMB	100 cfm	100 cfm
Manual 8 Stick PFT and CERES VMB used for Hydrogen (H_2)	50 cfm	--
CERES Hi-Flow H2 VMB		N/A
CERES Ultra Hi-Flow H2 VMB		N/A
PFT and CERES Storage/Leaker cabinet	100 cfm	100 cfm

NOTE: The S2 report or tracer gas test report will be used to determine the air-flow requirements for GCs and VMBs that are provided by other manufacturers.

6.8 GCs shall be made of 12-gauge steel, grounded, and the door(s) must be self-closing.

- GCs shall be provided with self-closing limited access ports or non-combustible windows to give access to equipment controls.
- The number of cylinders contained in a single GC shall not exceed three.
- GCs shall be operated at a negative pressure in relation to the surrounding area.

6.9 Gas cylinder valves connections must be installed as prescribed by the Compressed Gas Association (CGA).

6.10 Fire suppression and detection in the form of a sprinkler head must be installed in GCs and VMBs containing flammable materials.

6.11 Lines carrying gases that have a health or reactivity rating of 3 or 4 must be double contained and be constructed of a material that is compatible with the materials they are carrying. Lines carrying gases that have a flammability rating of 4 may be single contained and be constructed of a material that is compatible with the materials they are carrying. Table 2 is a reference list of the gases used onsite and whether the lines need to be single or double walled.

6.12 When using gases that are considered pyrophoric such as Silane, the gas delivery line needs to have a dedicated bottled nitrogen purge line that is monitored and will shut down the gas upon failure. The delivery line must also have a vent line that is designed to provide a 100:1 dilution, if activated.

6.13 Specialty gases are eligible for subfab installation if they have a vapor pressure of ≤15 psi at 68 °F or if they do not require a cabinet and/or a VMB (i.e., inert).

6.14 Pyrophoric and highly toxic gases are **NOT** permitted in the subfab.

6.15 As an integral part of the equipment, inert gas purge of gas delivery lines internal to the equipment are required to have a dedicated purge channel conforming to Table 2. These channels shall not be connected internally to any house bulk gas supplies unless EHS and the HPM System Engineer review and determine there are controls robust enough to mitigate the mixing of incompatibles and contaminating the house N_2 system.

A dedicated bottle purge system for each of the required purge channels must be provided as part of equipment installation and is typically outside the scope of equipment suppliers. Such internal purges shall be manifolded to a single, dedicated, external point-of-connection (POC) for each purge channel type required of the tool unless EHS and the HPM System Engineer review and determine there are controls robust enough to mitigate the mixing of incompatibles and contaminating the house system in which case house N_2 will be approved to be utilized.

6.16 All purges that are approved to use house N_2, after review and approval by EHS and the HPM System Engineer, will be maintained by EHS on the shared drive as a living Excel file.

6.17 Each purge line is to be monitored using fail-safe technology that will shut down the gas(es) upon failure.

- Any deviation from Table 2 must be approved by EHS and the HPM Systems Engineer prior to installation.

7. RFO AND EXCESS FLOW CONTROL

7.1 RFOs shall be installed on all gas cylinders that carry corrosives, silanes / pyrophorics, highly toxics, or flammables. RFO sizes used are common to the semiconductor industry by gas type.

- Exceptions are considered based on process need and exhaust system capacity for the installation location. Table 2 contains a reference list of RFO sizes by gas.

7.2 Excess flow switch shall be installed and tested on all lines carrying gases or liquids at >15 PSIG which have a NFPA hazard ranking of class 3 or 4 for health or reactivity, or class 4 for flammability.

- Table 2 contains a reference list of gases and whether excess flow control is required. Size and type shall be determined by the flow of gas required by the process.

7.3 HPM Gas Cylinder outlets feeding VMB shall have an RFO installed in accordance with the safety requirements (SEMI S2, S6, etc.) of the VMB.

7.4 HPM Gas Cylinder outlets feeding a tool's GIB (home run and non-home run connection) shall have an RFO installed in accordance with the safety requirements of the tool's GIB.

7.5 HPM VMB outlets feeding a tool's GIB shall have an RFO installed in the VMB outlet stick in accordance with the safety of the tool's GIB.

7.6 HPM Gas Cylinder outlets feeding a GIB shall have an RFO installed in the outlet in accordance with the safety requirements of the GIB.

7.7 RFOs should be sized as small as possible to meet process flow requirements as well as the requirements previously listed.

7.8 Specialty gases with a vapor pressure of ≤15 psi at 68 °F do not require RFOs.

8. CHEMICAL DISPENSE UNITS (CDU), VALVE MANIFOLD BOXES (VMB), AND LIQUID DISPENSE SYSTEMS (LDS)

8.1 The following requirements shall apply to CDUs, VMBs, LDS and Splitter / T-boxes used for storing or otherwise containing liquids with an NFPA rating of 3 or 4 for health or reactivity, or 4 for flammability, unless otherwise noted.

- Units must have liquid leak switches/detectors that are interlocked to shut off flow and send an alarm back to the AAC.
- Units must have exhaust flow/pressure switches that are interlocked to shut off flow and send an alarm back to the AAC. The only exception to this requirement is T-boxes, which are not exhausted.
- Units must be equipped with an EMO button. This EMO must be hard wired to the respective unit and have the ability to send signals to tool’s AAC, CDUs AAC, and/or VMBs AAC. The only exception to this requirement is T-boxes which have no power.

- Units must be equipped with a secondary containment to be able to contain ≥110% of the largest container and be provided with drainage to a bulk waste tank, a disposal area, or to a treatment plant. The only exception to this requirement is T-boxes, which are enclosed, but not connected to a drain.

8.2 **Materials of Construction**

- If flammable or pyrophoric, the unit must be made of at least 18-gauge steel, be double-walled (only required for bulk systems [systems with drums >55 gallons]), be self-closing, and be grounded. Containers, bubblers, or drums used inside such cabinets must be constructed of steel. Vessel and delivery lines should be grounded and electrically inter-connected. Delivery lines should also be conductive and should not have a non-conductive liner.

- If corrosive the unit must be made of FM 4910 fire retardant plastic and be liquid tight. Containers/drums used inside storage cabinets must be constructed with a poly plastic or Teflon based on compatibility with the material contained. The outside of the drum is to be constructed of a material to maximize structural strength and allow for ease of handling in service.

8.3 **Fire suppression and detection must be installed under the following conditions:**

- If the flammable unit is made of a combustible material, then fire suppression shall be used.

- If more than 30 gallons of a flammable material is needed at a closed system workstation or is part of a workstation, fire suppression must be installed to increase the allowable flammable material amount to 60 gallons (*2020 NYS Fire Code Section 2705.2.2*).

- If more than 50 gallons of corrosive material is needed at a closed system workstation, then fire suppression must be installed to increase the allowable corrosive material amount to 100 gallons (*2020 NYS Fire Code Section 2705.2.2)*.

8.4 Heat detection shall be provided in units that use flammable liquids. Heat detectors shall be mounted on the exhaust duct and set to 120 °F. Flame detection will be in the form of snap switches and must be wired back to the AAC for monitoring.

- UVIR or dual IR detectors and/or Very Early Smoke Detection Apparatus (VESDA) shall be installed in units that house pyrophoric or water reactive materials.

8.5 The average velocity of a CDU, VMB, or LDS taken at the face of access ports shall be 200 feet per minute (fpm) with a minimum of 150 fpm at any access port.

8.6 Lines carrying liquids that have a health or reactivity rating of 3 or 4 must be double contained and be constructed of a material that is compatible with the materials they are carrying.

8.7 Lines carrying liquids that have a flammability rating of 4 must be single contained and be constructed of a material that is compatible with the materials they are carrying.

8.8 In general, stainless steel shall be used for flammable materials and plastic for corrosive materials. If the lines are not double walled then secondary containment must be provided.

8.9 If secondary containment is not provided then fire suppression shall be used.

8.10 All Teflon lines must be double contained.

9. VAPOR DRAW SYSTEMS

9.1 Vapor draw systems must have door switches installed per Table 1 unless alternate methods of protection are documented and approved by EHS prior to the door switches being removed.

9.2 Vapor draw source boxes housing sub-atmospheric ampoules or cylinders where pressure detection is integrated into box may have the door switches removed without prior approval.

10. FLAMMABLE STORAGE CABINETS

Design and construction of Class I flammable and Class II combustible liquid storage cabinets shall be in accordance with this section.

10.1 **Materials of Construction**:

- Cabinets shall comply with OSHA 1910.106(d)(3)(ii)(a) or be constructed of approved wood or metal.

- Unlisted metal cabinets shall be constructed of steel having a thickness of not less than 0.044 inch (1.12 mm, 18 gauge). The cabinet, including the door, shall be double walled with 1.5-inch (38 mm) airspace between the walls. Joints shall be riveted or welded and shall be tight fitting.

10.2 **Labeling:** Cabinets shall be provided with a conspicuous label in red letters on contrasting background which reads: FLAMMABLE - KEEP FIRE AWAY.

10.3 **Doors:** Doors shall be well-fitted, self-closing, and equipped with a three-point latch.

10.4 **Bottom:** The bottom of the cabinet shall be liquid tight to a height of at least 2 inches (51 mm), or 110% of the volume of the largest container.

10.5 **Capacity:** The combined total quantity of liquids in a cabinet shall not exceed 120 gallons, with not more than 60 gallons being Class I or II liquids.

10.6 **Number of storage cabinets**: No more than three storage cabinets shall be located in a single fire area. Additional cabinets are allowed to be located in the same fire area if the additional cabinets (or groups of up to three cabinets) are separated from other cabinets or groups of cabinets by at least 100 feet.

11. FLAMMABLE / COMBUSTIBLE STORAGE REFRIGERATORS AND FREEZERS

All refrigerators and freezers installed on site must be listed and meet all relevant regulatory and/or NFPA requirements for flammable storage.

12. LIQUID WASTE SYSTEMS

The following is a list of the requirements for installing a liquid waste handling system:

- Level controls shall be provided on collection drums/totes and capable of sending an alarm to the AAC if a high liquid level is achieved.
- Leak detection and exhaust flow pressure switches shall be provided and be interlocked to alarm at the tool(s) and AAC.
- Secondary containment shall be provided.
- In general, stainless steel shall be used for flammable materials and plastic for corrosive materials.

- Flammable waste cabinets must be made of 18-gauge steel, double-walled (bulk systems only), self-closing, grounded, and have fire detection.

- Flammable drums used inside such cabinets must be constructed of steel.

- Corrosive waste cabinets must be made of FM4910 approved plastic.

- Corrosive drums used inside such cabinets must be constructed of polyurethane.

- Lines must be double contained and constructed of a material that is compatible with the materials they are carrying. Stainless-steel lines only, may be single-walled, if fully welded.

- If the lines carrying hazardous wastes are not double-walled, then secondary containment must be provided. If secondary containment is not provided, then fire suppression must be used.

13. O_3 GAS GENERATORS

O_3 gas generators having a maximum ozone-generating capacity of 0.5 lb. (0.23 kg) or more over a 24-hour period shall be in accordance with this section.

13.1 **Design:** O_3 gas generators shall be designed, fabricated, and tested in accordance with NEMA250.

13.2 **Location:** O_3 generators shall be located in approved cabinets or O_3 generator rooms.

- EXCEPTION: An O3 gas generator within an approved pressure vessel when located outside of buildings.

13.3 **Cabinets:** O_3 cabinets shall be constructed of approved materials and compatible with O_3. Cabinets shall display an approved sign stating: OZONE GAS GENERATOR - HIGHLY TOXIC - OXIDIZER.

- Leak detection and exhaust flow pressure switches should be provided and be interlocked to alarm at the tool(s) and at the AAC. Liquid generation requires only Fab level ambient gas detection. Gas generation requires ambient and exhaust gas detection.

- Cabinets shall be braced for seismic activity.

- Cabinets shall be mechanically ventilated with a minimum of six air changes per hour.
- The average velocity of ventilation at makeup air openings with cabinet doors closed shall not be <200 fpm.

13.4 **O_3 Gas Generator Rooms:** Shall be mechanically ventilated with a minimum of six air changes per hour and equipped with a continuous gas detection system, which will shut off the generator and sound a local alarm when concentrations rise above the permissible exposure limit.

- O3 gas generator rooms shall not be normally occupied and kept free of combustible and hazardous material storage.
- Room access doors shall display an approved sign stating: OZONE GAS GENERATOR - HIGHLY TOXIC - OXIDIZER.

13.5 **Piping, Valves, and Fittings shall be in accordance with the following:**

- Piping shall be welded stainless steel piping or tubing. Except double-walled piping, and piping, valves, fittings, and related components located in exhausted enclosures.
- Piping materials shall be compatible with O3 and shall be rated for the design operating pressures.
- Piping shall be identified with the following: OZONE GAS - HIGHLY TOXIC - OXIDIZER.

13.6 **Automatic Shutdown: O_3 gas generators shall be designed to shut down automatically under the following conditions:**

- When the dissolved O_3 concentration in the water being treated is above saturation when measured at the point where the water is exposed to the atmosphere.
- When the process using generated O_3 is shut down.
- When the gas detection system detects O_3.
- Failure of the ventilation system for the cabinet or generator room.
- Failure of the gas-detection system.

13.7 **Manual Shutdown:** Manual shutdown controls shall be provided at the generator and, when in a room, within 10 feet of the main exit or exit access door.

14. PYROPHORIC OR WATER REACTIVE LIQUID DISPENSE CABINETS (PRECURSORS)

14.1 **Cabinets that dispense or use water reactive or pyrophoric liquids shall be installed with the following:**

- Liquid leak detection that will automatically shut off the dispensing system upon detection.
- Delivery lines shall be constructed of high melting point materials such as 316L SST, which has a melting point of ~1400 °C.
- Only DOT approved metal containers (stainless steel ampoules can withstand 1200 PSIA or similar) for liquid storage in the dispensing cabinet.

  The gas inlet and liquid outlet on dispense containers/ampoules must meet the requirements set forth in the SEMI F96-0704 standard.

  In summary, the standard states that such containers shall be equipped with a gas inlet and liquid outlet port. The ports shall be located such that the dip tube is at the 3 o'clock position and the gas inlet at the 9 o'clock position. Both ports shall be fitted with ¼" OD face-seal connectors. The connectors shall be male on the gas inlet port and female on the dip tube port.
- A fast-acting, high-sensitivity, smoke detection system (HSSD) or VESDA to quickly detect the products of combustion expected as a result of a water reactive/pyrophoric liquid leak. This system should be capable of providing a hard-wired interface to the cabinet to automatically shut off the dispensing system upon detection.
- Chemical cabinets shall only be installed in buildings that are protected by an automatic sprinkler system.
- The volume of water reactive/pyrophoric liquid at the workstation/tool shall be limited to ≤1.89 liters (0.5 gallons) (2020 NYS Fire Code Section 2705.2.2).
- Normally closed pneumatically operated valves in the chemical supply lines that fail safe in the closed position.
- If chemical delivery from the cabinet to the workstation/tool uses a carrier gas, the carrier gas shall be equipped with an overpressure switch which will automatically shut off the dispensing system if the switch sees a rise in pressure in the carrier piping.

- Chemical cabinets shall be made from ≥12 gauge (.097 inch) stainless steel and be provided with a door interlock that shuts the supply valve in the event the cabinet doors are opened.
- Chemical cabinets shall be provided with continuous exhaust ventilation. Such exhaust shall be provided with a flow and heat monitoring device via the AAC. Both monitoring devices shall be interlocked to shut off the supply valves in the event of an alarm condition.
- Chemical cabinets shall be provided with secondary containment and with an EMO button, which when activated will automatically shut off the dispensing system and place the entire system in a safe shutdown condition.
- The fire detection systems shall be monitored by the building Fire Alarm Control Panel (FACP) and shall provide an automatic text message at the FACP, and via the electronic paging system, to the Emergency Response Team (ERT) describing the location of the workstation / tool in the event of an alarm.
- Precursors shall be purged or pushed with the manufacturer specified purge channel gas or the approved house N2, argon, or helium.

15. POLLUTION CONTROL AND/OR ABATEMENT DEVICES

The purpose of this section is to provide general guidance on the minimum requirements and selection criteria for the abatement of the various process chemistries used in the semiconductor industry that could potentially be used on site, in accordance with *SEMI F5-1101*.

15.1 **Process Chemicals**: Process chemicals can generically be divided into nine categories:

1) Hydrides
2) Volatile Organic Compounds (VOCs)
3) Flammables
4) Pyrophorics
5) Corrosives
6) Toxic / Highly Toxic
7) Metal Organic
8) Perfluorinated Compounds (PFCs)
9) Nitric Oxide and Nitrogen Dioxide (NOx)

15.2 **Abatement Devices**: Process chemicals may be effectively abated by one or more technologies. The choice of technology will be driven by several considerations:

- Abatement of the waste stream to acceptable levels
- The potential creation of new waste stream as a result of the abatement
- Cost of ownership (upfront and ongoing)
- Utility usage
- Facility impacts and limitations
- More than one Point-of-Use (POU) device may abate the waste stream to acceptable levels. The proposed abatement will be evaluated for its potential impact on the Facilities' utilities and waste streams. EHS should be consulted for questions, concerns, and current best practices used at the earliest planning stage.
- Table 3 illustrates the EHS and industry recommended POU abatement technologies for the various process chemicals currently used as well as the post treatment end of pipe exhaust system type.
- Required Destruction Removal Efficiencies (DRE) and POU specifications are based on the minimum guidelines set forth in 40 CFR §63, Subpart BBBBB of the National Emission Standards for Hazardous Air Pollutants for Semiconductor Manufacturing. The site has also adopted and implemented additional guidelines for the NFX building POU installations per the NFX Cleanroom Project Statement of Requirements (SOR).

15.2.1 <u>Tools requiring POU Abatement Systems:</u>

- Shall place POU Abatement Systems in the Subfab when one exists for space consideration.
- Shall use a maximum average water usage of no more than 0.5 gpm.
- POU Scrubbers shall use Industrial City Water (ICW).
- POU Scrubber drains should be equipped with pumps with a minimum 20 ft. static head. If the drain pressure exceeds 15 psig, it shall be constructed of double walled-lines with leak detection.

- POU Thermal/Wet Abatement systems shall discharge wastewater to the Fluoride Waste (FW) drain in the building unless approved otherwise by EHS and the Facilities Engineering Group (FEG).
- POU Abatement Systems shall meet the following minimum Destruction Removal Efficiencies (DRE) per 40 CFR § 63.7184:
  - Organic Hazardous Air Pollutants >98%, 20 parts per million by volume (ppmv).
  - Inorganic Hazardous Air Pollutants >95%, 0.42 ppmv.
  - CF_4 >90%.
  - All DRE calculations must include by-products produced in POU systems (e.g., - HF emission as a result of treating SiF_4 or CF_4 or any other fluorinated compound).
  - There may be additional, more restrictive, DRE requirements contained in the SOR for a building.
- POU scrubbers must minimize the moisture or aerosol carry-over into the facilities duct system. When this is expected to occur, it must be identified in the tool hook-up design.
- Maintenance of local POU scrubbers shall be by the Supplier, Tool Owner (TO), or designated scrubber owner.

15.2.1.1 The following are Special POU requirements for PFCs and other Fluorine bearing process chemistries:

- PFCs and/or other fluorine bearing process chemistries shall be abated in a POU thermal combustion/wet scrubber device that is capable of combustion in “high fire” mode.
- The device will be required to switch from low fire to high fire mode, based upon a signal from the tool chamber that indicates that PFCs and/or other fluorine bearing process chemistries are in use.
- The POU device shall function in low fire mode at all other times.

15.3 TO and/or Equipment Owners shall submit **EHS-00016-F1** to EHS for a review of process chemistries and proposed abatement technologies before the installation of said technology for new and existing chemistry and/or processes.

15.4 **Bypass Mode**: In the event that a POU Scrubber Faults, all gases shall by-pass to the Acid Exhaust with coated ductwork in the building, unless an exception is approved by EHS and the FEG System Owner. Each request will be evaluated on a case-by-case basis.

- EHS will not allow the following gases to enter house exhaust systems unabated without an immediate shutdown of the processing tool:

- Pyrophoric materials (i.e., Silane above 1.42%)
- Greater than 15% of the lower explosive limit (LEL) for flammable gases
- 20% F2
- Highly toxic materials (NFPA Health rating of 4)

15.5 Additional interlocks may be required beyond normal TGMS requirements for “run-out” to be allowed. New materials, processes, and chemistries will need to be evaluated on a case-by-case basis, and a “run-out” time limit will be required. EHS will only evaluate requests for “run-out” of a specific tool that has a completed design, with defined chemistry. “Run-out” will only be considered for wafer processing runs and will never be allowed for chamber cleans.

16. HYDROGEN (H_2) DILUTION AND ABATEMENT

16.1 H_2 gas is highly flammable and potentially explosive under certain circumstances. H_2 gas has an explosive range of between 4% and 96% concentration in air. If H_2 is released to either the ambient air inside the building or into exhaust ductwork above the LEL, all that is required is a heat source, spark, or open flame to ignite the gas. This could result in personal injury and/or damage to equipment and facilities.

16.2 The site utilizes H_2 gas detectors which are tied to our Toxic Gas Monitoring System (TGMS) to alert the ERT and Security if H_2 gas levels exceed 15% of the LEL (0.6%) in order to provide enough warning to react to increasing concentrations before the LEL is reached.

16.3 When unreacted H_2 gas is discharged from a tool chamber, it is imperative to reduce the concentration to below the LEL of 4.4% before it reaches a vacuum pump or other source of heat or spark.

16.4 Since H_2 is typically purged from the process chambers with N_2, it is usually much lower than 100% concentrations in the exhaust. It is preferable to have continuous exhaust/discharge piping with welded rather than mechanical joints between the tool chamber(s) and exhaust duct(s) to avoid leakage into ambient air where it can react with O_2. If routed through a vacuum pump, welded piping is not required since these lines are typically under vacuum.

16.5 The site policy is to reduce the H_2 concentration to <4.4% at the vacuum pump by dilution with N_2.

- Vacuum pumps expected to process H_2 or other flammable gases are typically purged with 30-50 liters per minute (lpm) of N_2 to reduce the concentration below the LEL and to protect the pump. To reduce the concentration of H_2 to <4%, a 25:1 dilution is required. Since most semiconductor processes use <1–2 lpm of H_2, 25-50 lpm of N_2 dilution at the pump is adequate under typical flows.

16.5.1 <u>Example Calculation:</u>

- 1 lpm H_2 (100%) + 25 lpm N_2 (100%) = 26 lpm with 96% N_2 and 4% H_2.
- 2 lpm H_2 (100%) = 50 lpm N_2 (100%) = 52 lpm with 96% N_2 and 4% H_2.

- Most pump manufacturers indicate pump purges with N_2 should not exceed 50 lpm as it will affect pump performance. If a process is flowing more than 2 lpm of H_2 through a process chamber, additional N_2 dilution will be needed to get below the 4.4% LEL at the pump. N_2 or CDA dilution must be monitored by flow meters and switches integrated to the AAC.

16.6 If the discharge from the vacuum pump goes directly to a thermal destruction abatement device, the exhaust gas does not need any dilution beyond the pump purge. Further dilution of the H_2 concentration makes thermal destruction less efficient and more energy intensive.

16.7 If the tool discharging H_2 does not have a thermal abatement device in which the H_2 can be destroyed, dilution with an inert gas like N_2 to below the LEL is the only safe alternative.

16.8 If the exhaust duct has a H_2 sensor downstream from the vacuum pump discharge, the H_2 level needs to be below the TGMS monitoring warning set point of 0.6% H_2 concentration. To reach that level, the exhaust gas can be diluted to less than the 4.4% LEL with N_2 and the rest of the way down to the 0.6% TGMS alarm level with ambient air. It does not need to be diluted entirely with N_2.

16.9 **Piping Systems**

- Piping systems shall be marked in accordance with ANSI A13.1.
- Markings used for piping systems shall consist of the content's name and include a direction-of-flow arrow.

- Markings shall be provided at each valve; at wall, floor, or ceiling penetrations; at each change of direction; and at a minimum of every 20 feet throughout the piping run.

17. CLEAN ENVIRONMENTS, HOODS, OR SIMILAR STRUCTURES

17.1 All structures raised off the floor (i.e., on legs) shall be carefully reviewed for compliance with fire sprinkler requirements to assure space beneath is adequately protected.

17.2 Any high temperature exhaust applications must be clearly defined in the P&ID and communicated to all System Owners affected.

17.3 Fan Filter Units (FFUs) or similar devices shall utilize cleanroom rated materials in filters. Supplemental filters shall be made of metal mesh or other fire-resistant materials, and all fans shall be covered by a protected cover or shield to prevent any accidental contact.

17.4 Structures shall be incorporated in the HEXID system and be appropriately labeled.

18. MAINTENANCE

18.1 Maintenance shall be performed on all equipment listed herein in accordance with the manufacturers and regulatory requirements.

18.2 Such maintenance should consist of at least the following:

- If available, functionality checks and/or tests of fire detection and suppression systems.

18.3 Functional tests of interlocks and safety devices such as, but not limited to, doors, pressure switches, exhaust flow, leak detectors, EMO buttons, coaxial lines, or gas sensor change outs.

19. RECORDS

19.1 Maintenance records of equipment, systems, and/or devices shall be kept on file by the owning department.

20. TABLES AND APPENDIX

20.1 **Table 1** - Equipment Installation Typicals

20.2 **Table 2** - Process Gas Installation Reference

20.3 **Table 3** - Point of Use Abatement Typical Installations

20.4 **Appendix A** - HPM Leak Integrity Requirements

Table 1. Equipment Installation Typicals

Equipment Type	Tie into AAC/FACP[4]	Delivery Lines	COAX	Fire Suppression/ Detection	Secondary Containment	Grounded	EMO	Materials of Construction	Exhaust Duct Material	Pneumatic Valves	BN2 Switch	Door Switches	Excess Flow Valve	Method of Drainage	Exhaust system	Purge Vents or Bypass
Gas Cabinets																
flammable	X	Stainless Steel		X		X	X	#12 Gauge Steel	Stainless Steel	X	X	X	X		HE	SE
pyrophoric	X	Stainless Steel	X	X		X	X	#12 Gauge Steel	Stainless Steel	X	X	X	X		HE	Rooftop
corrosive/oxidizer/toxic	X	Stainless Steel	X				X	#12 Gauge Steel	Stainless Steel	X	X	X	X		HE	AE/BE
highly toxic	X	Stainless Steel	X				X	#12 Gauge Steel	Stainless Steel	X	X	X	X		HE	AE
Gas VMB																
flammable	X	Stainless Steel		X		X	X	Steel	Galvanized	X	X	X	X		HE	SE
pyrophoric	X	Stainless Steel	X	X		X	X	Steel	Galvanized	X	X	X	X		HE	Rooftop
corrosive/oxidizer/toxic	X	Stainless Steel	X				X	Steel	Galvanized	X	X	X	X		HE	AE/BE
highly toxic	X	Stainless Steel	X				X	Steel	Galvanized	X	X	X	X		HE	AE
GIB Boxes		Stainless Steel				X	X	Steel	Galvanized	X	X	X			HE	AE
Liquid Dispense Cabinet/Pre-Cursor/Vaporizers (Fire suppression only if >30 gallons in total[3])																
flammable	X	Stainless Steel		X[3]	X	X	X	#18 Gauge Steel	Galvanized	X	X	X[6]			HE	SE
pyrophoric	x[4]	Stainless Steel	X	X[2]	X	X	X	#18 Gauge Steel	Stainless Steel	X	X	X[6]			HE	Rooftop
corrosive/oxidizer/toxic	X	Stainless Steel	X	X	X		X	#18 Gauge Steel	Galvanized	X	X	X[6]			AE	AE/BE
highly toxic	X	Stainless Steel	X	X	X		X	#18 Gauge Steel	Galvanized	X	X	X[6]			AE	AE
Chemical Dispense Unit (CDU)																
corrosive/oxidizer	X	PFA/PVC	X		X		X	Polyurethane	Lined Stainless			X	X	X	CE	NA
flammable/combustible	x[4]	Stainless Steel		X	X	X	X	#18 Gauge Steel	Stainless Steel			X	X	X	CE	NA
Chemical Valve Manifold Box (VMB)																
corrosive acid/oxidizer	X	PFA/PVC	X		X		X	Polyurethane	PVC			X	X	X	AE	NA
Corrosive basic/ oxidizer	X	PFA/PVC	X		X		X	Polyurethane	PVC			X	X	X	BE	NA
flammable/combustible	X	Stainless Steel		X	X	X	X	Steel	Stainless Steel			X	X	X	SE	NA
Chemical T/Splitter - Box																
corrosive/oxidizer	X	PFA/PVC	X		X		X	Steel	PVC			X		X	NA	NA
flammable/combustible	X	Stainless Steel		X	X	X	X	Polyurethane	Stainless Steel			X		X	NA	NA
Waste Collection Unit																
flammable	x[4]	Stainless Steel	X?	x[3]	X	X	X	#18 Gauge Steel	Stainless Steel			X		X	SE	NA
corrosive/oxidizer/toxic	X	PFA/PVC	X?		X		X	Polyurethane	PVC			X		X	AE	NA
Ozone Generator (Gas Only)	X	Stainless Steel	X				X	Steel	Galvanized	X		X	X		AE	AE
Ozone Generator (Ozonated Water)	X	PFA/PVC	X				X	Polyurethane	PVC			X	X	X	HE	NA
Point of Use Scrubbers	X	Stainless Steel					X	#18 Gauge Steel	Galvanized/ Stainless Steel			X		X	AE	HE[5]

NOTES:

1 - Blank

2 - Use a fast acting high sensitivity smoke detection system (HSSD) or very early smoke detection (VESDA)

3 - Fire suppression shall only be installed in cabinets that house >30 gallons of a flammable material

4 - Fire detection alarms shall be tied to the AAC and the FACP

5 - Heat exhaust may be allowed for scrubber bypass by EHS on a case by case basis

6 - Per S2 LDS alternative door switch methods are acceptable if they provide an equivalent level of hazard control, so without the door switches if the exposure controls can be documented and are equivalent then the door switches can be removed.

NOTE: Please refer to TGMS Typical Installation Worksheet, EHS-000031 TGMS Operation and Maintenance Specification, Appendix C for further information on Gas Detection, Heat Detection, Exhaust Flow Monitoring and UV/IR requirements.

Stainless Steel: 316L Stainless Steel shall be used for all delivery lines
PFA/PVC: Perfluoroalkoxy/Polyvinylchloride
Lined Stainless Steel: Stainless Steel ductwork with Teflon lining

Exhaust Systems: AE - Acid Exhaust, BE- Base Exhaust, CE - Cabinet Exhaust (combined), HE - Heat (general) Exhaust, SE - Solvent Exhaust, NA - Not applicable.

Table 2 - Process Gas Installation Reference

Gas	Gas	State	NFPA 704 HEALTH	NFPA 704 FIRE	NFPA 704 INSTABILITY	Classification: Toxic(T), Corrosive (CO), Pyrophoric (P), Flammable (F), Inert (In), Oxidizer (Ox), Reactive (R)	Containment: Single (S) Double (D)	RFO[7,8]	Excess Flow Switch	Purge Channel for GCs, VMBs, and GIBs[9,10]
0.8% Phosphine in He	PH3 (0.8%) in He	G	4	3	0	F,T	S	0.010	Y	Flammable
1% Arsine in H2	AsH3 1% in H2	G	4	4	0	T,F	D	0.010	Y	Flammable
1% Diborane in H2	B2H6 1% in H2	G	4	4	4	T,F	D	0.010	Y	Flammable
1% Flourine in N2	F2 (1%) in N2	G	4	0	2	T,CO,OX	D	0.010	Y	Corrosive
1% Phosphine in Ar	PH3 (1%) in Ar	G	4	3	0	F, T	D	0.010	Y	Flammable
1% Phosphine in He	PH3 (1%) in He	G	4	3	0	F, T	D	0.010	Y	Flammable
10% Diborane in He	B2H6 10% in He	G	4	4	4	T,F	D	0.010	Y	Flammable
10% Germane in H2	GeH4 (10%) in H2	G	4	4	4	T,F	D	0.010	Y	Flammable
10% Hydrogen in Ar	H2 10% in Ar	G	0	4	0	F	S	**No**	Y	Flammable
10% Methane in Ar	CH4 10% in Ar	G	0	4	0	F	S	0.010	Y	Flammable
10% Phosphine in Ar	PH3 (10%) in Ar	G	4	3	0	F,T	D	0.010	Y	Flammable
10% Phosphine in H2	PH3 (10%) in H2	G	4	3	0	F, T	D	0.010	Y	Flammable
10% Silicon Tetrafluoride	10%SiF4 in N2	G	3	0	2	CO,T	D	0.020	Y	Corrosive
10% Trimethylsilane in Ar	CH3SiH3 10% in Ar	G	2	4	1	F	D	0.010	Y	Flammable
10% Trimethylsilane in H2	CH3SiH3 10% in H2	G	2	4	1	F	D	0.010	Y	Flammable
20% Fluorine in Ar	F2 (20%) in Ar	G	4	0	2	T,CO,OX	D	0.010	Y	Corrosive
20% Fluorine in N2	F2 (20%) in N2	G	4	0	2	T,CO,OX	D	0.010 or 0.016	Y	Corrosive
20% Trimethylsilane in H2	CH3SiH3 20% in H2	G	2	4	1	F	D	0.010	Y	Flammable
3% Fluorine in N2	F2 (3%) in N2	G	4	0	2	T,CO,OX	D	0.010	Y	Corrosive
3% Hydrogen in N2	H2 3% in N2	G	0	1	0	IN	S	**No**	**N**	Inert
4% Hydrogen in N2	H2 4% in N2	G	0	1	0	IN	S	**No**	**N**	Inert
5% Diborane in Ar	B2H6 5% in Ar	L	4	4	4	T	D	0.010	Y	Flammable
5% Diborane in H2	B2H6 5% in H2	L	4	4	4	T,F	D	0.010	Y	Flammable
5% Diborane in N2	B2H6 5% in N2	G	4	4	4	T,F	D	0.010	Y	Flammable

5% Helium in N2	He 5% in N2	G	1	0	0	IN	S	**No**	**N**	Inert
5% Hydrogen in He	H2 5% in He	G	0	1	0	IN	S	**No**	**N**	Inert
5% Phosphine in Ar	PH3 (5%) in Ar	G	4	3	0	F, T	D	0.010	Y	Flammable
5% Phosphine in He	PH3 (5%) in He	G	4	3	0	F,T	D	0.010	Y	Flammable
5% Trimethylsilane in Ar	CH3SiH3 5% in Ar	G	2	4	1	F	D	0.010	Y	Flammable
Acetylene	C2H2	G	0	4	0	F	D	0.010	Y	Flammable
Ammonia	NH3	L	3	4	0	F, CO	D	0.040	Y	Flammable
Argon	Ar	G	1	0	0	IN	S	**No**	**N**	Inert
Argon/Neon/Xenon	Ar/Ne/XE	G	1	0	0	IN	S	**No**	**N**	Inert
Arsine	AsH3	L	4	4	0	T,F	D	0.010	Y	Flammable
Boron Trichloride	BCl3	L	3	0	1	CO	D	**No**	**N**	Corrosive
Boron Trifluoride	BF3	G	4	0	1	CO,T	D	0.010	Y	Corrosive
Butene	C4H8	L	0	4	0	F	S	**No**	Y	Flammable
Carbon Dioxide	CO2	L	0	0	0	IN	S	**No**	**N**	Inert
Carbon Monoxide	CO	G	2	4	0	F,T	D	0.020	Y	Flammable
Carbonyl Sulfide	COS	L	3	4	1	F,T	D	**No**	Y	Flammable
Chlorine	Cl2	L	4	0	0	OX,T	D	0.020	Y	Oxidizer
Chlorine Trifluoride	ClF3	L	4	0	3	OX,T	D	**No**	Y	Oxidizer
Deuterated Ammonia	ND3	G	3	4	0	F,CO	D	0.010	Y	Flammable
Deuterium	D or H2	G	0	4	0	F	S	**No**	Y	Flammable
Diborane	B2H6	G	4	4	4	T,F, P, CO, WR	D	0.010	Y	Pyrophoric
Dichlorosilane	SiH2Cl2	L	4	4	1	F,T,CO, WR	D	**No**	**N**	Corrosive
Difluoromethane	CH2F2	L	0	4	0	F	S	0.010	Y	Flammable
Digermane	Ge2H6	G	3	4	3	T,F	D	0.010	Y	Flammable
Disilane	Si2H6	G	0	4	1	P,F	D	**No**	**N**	**Silane**
Ethylene	C2H4	G	2	4	2	F	S	0.010	Y	Flammable
Fluorine/Argon/Neon mix	F2/Ar/Ne	G	4	0	2	T,CO,OX	D	0.010	Y	Corrosive
Forming Gas	H2/N2 (4% H2 in N2)	G	0	0	0	IN	S	No	**N**	Inert
Germane	GeH4	L	4	4	4	T,F, WR	D	0.010	Y	Flammable
Germanium Tetraflouride	GeF4	L	3	0	1	T, CO	D	0.010	Y	Toxic
Helium	He	G	1	0	0	IN	S	**No**	**N**	Inert
Hexafluro-1,3-butadiene	C4F6	L	3	4	0	F,T	D	**No**	**N**	Flammable
Hydrogen	H2	G	0	4	0	F	S	**No**	Y	Flammable
Hydrogen Bromide	HBr	L	3	0	0	CO	D	0.020	Y	Corrosive

Hydrogen Chloride	HCl	L	3	0	0	CO	D	0.020	Y	Corrosive
Hydrogen Fluoride	HF	L	3	0	2	CO,T	D	**No**	**N**	Corrosive
Hydrogen Sulfide	H2S	L	4	4	0	F,T	D	0.010	Y	Flammable
Isoprene	C5H8	L	1	4	2	F,T	D	0.100	Y	Flammable
Krypton	Kr	G	0	0	0	IN	S	**No**	**N**	Inert
Methane	CH4	G	0	4	0	F	S	0.010	Y	Flammable
Methyl Chloride	CH3Cl	L	3	4	1	F, T	D	0.010	Y	Flammable
Methyl Fluoride	CH3F	L	1	4	0	F	S	0.010	Y	Flammable
Monomethyl Silane	MMS	L	3	4	2	F, T	D	0.010	Y	Flammable
Neon	Ne	G	0	0	0	IN	S	**No**	**N**	Inert
Nitric Oxide	NO	G	4	0	0	OX,T	D	0.020	Y	Oxidizer
Nitrogen	N2	G	1	0	0	IN	S	No	**N**	Inert
Nitrogen (liquid)	N2	L	3	0	0	IN, Cryo	S	**No**	**N**	Inert
Nitrogen Trifluoride	NF3	G	3	0	0	OX,T	D	0.010	Y	Oxidizer
Nitrous Oxide	N2O	L	2	0	0	OX	S	**No**	**N**	Oxidizer
Octafluorocyclobutane	C4F8	L	1	0	0	IN	S	**No**	**N**	Inert
Octafluorocyclopentene	C5F8	L	3	0	1	T	D	**No**	Y	Toxic
Octafluoropentane	C3F8	G	2	2	0	F	D	0.010	**N**	Flammable
Oxygen	O2	G	0	0	0	OX	S	**No**	**N**	Oxidizer
Oxygen (liquid)	O2	L	3	0	0	OX, Cryo	S	**No**	Y	Oxidizer
Ozonated Water	O3*	L	4	0	0	OX, T	D	**No**	Y	Oxidizer
Ozone	O3	G	4	0	0	OX, T	D	0.010	Y	Oxidizer
Pentene	C5H10	G	0	4	0	F	S	No	Y	Flammable
Phosphine	PH3	L	4	4	0	P,F,T	D	0.010	Y	Pyrophoric
Phosphine	1% PH3/N2	G	4	3	0	F,T	D	0.010	Y	Flammable
Propane	C3H8	L	2	4	0	F	S	0.010	Y	Flammable
Propylene	C3H6	G	1	4	0	F	S	0.010	Y	Flammable
Silane	SiH4	G	0	4	1	P,F	D	0.010	Y	**Silane**
Silicon Tetrachloride	SiCl4	L	3	0	1	CO	D	**No**	Y	Corrosive
Sulfur Dioxide	SO2	L	3	0	0	CO,T	D	0.030	Y	Corrosive
Sulfur Hexafluoride	SF6	L	1	0	0	IN	S	**No**	**N**	Inert
Tetraethyl orthosilicate	TEOS	L	2	2	1	IN	S	**No**	Y	Inert
Tetrafluoromethane (Freon 14) (Carbon	CF4	G	2	0	0	IN	S	**No**	**N**	Inert

Tetrafluoride)										
Tetrafluoropropene	C3H2F4	L	0	1	0	IN	S	**No**	**N**	Inert
Trichlorosilane	TCS	L	3	4	2	F, T	D	**No**	Y	Flammable
Trifluoroiodomethane	CF3I	L	2	0	0	IN	S	**No**	**N**	Inert
Trifluoromethane (R23)	CHF3	L	1	0	1	IN	S	**No**	**N**	Inert
Trimethylaluminum	TMA	l	3	4	4	P, T, WR	D	**No**	**N**	Pyrophoric
Trimethylsilane	CH3SiH3	G	2	4	1	F	D	**No**	**N**	Flammable
TRISILYLAMINE	TSA	L	4	4	3	F, T, WR	D	**No**	Y	Flammable
Tungsten Hexafluoride	WF6	L	4	0	1	T,CO	D	**No**	**N**	Toxic
Xenon	Xe	G	0	0	0	IN	S	**No**	**N**	Inert

Notes:

1. All gas lines shall be constructed of stainless steel.
2. All liquid chemical lines that are pressurized to 15 psi or greater that carry NFPA Health and Reactivity rating of 3 or 4 must be double contained plastic.
3. All liquid chemical lines that are pressurized to 15 psi or greater that carry NFPA Flammable rating of 4 must be single walled stainless.
4. Pyrophorics highlighted in yellow.
5. Armaflex 1/2" will be used for insulation of lines. This may have to be modified for C5H10 and SiCl4 to 1".
6. Only lines identified that require heat tracing are BCl3 and SiCl4.
7. An RFO shall be installed in the gas cylinder valve not to exceed 0.030" for corrosives and not to exceed 0.010" for silane/pyrophorics, highly toxics, and flammables for gases with a vapor pressure >15 psi at 68 F.
8. RFOs at the tool are to be determined based on the tracer gas test for the tool. This column is only for facility cabinets and VMBs.
9. To use an alternate purge channel, the Toxic Gas Manager and EHS must approve the variation.
10. This is the primary purge channel — an alternate may be designated by the HPM System Engineer and EHS in the event there are incompatibilities within the purge channel.

* Determined that the hazard ratings for ozonated water are the same as ozone gas.

When materials are used outdoors in above-ground piping systems or within buildings, they shall be in accordance with ANSI B31.9 and one of the following:

A. Suitably protected against fire exposure.
B. Located where leakage from failure would not unduly expose people or structures.
C. Located where leakage can be readily controlled by operation of accessible remotely located valves. In all cases, nonmetallic piping shall be used in accordance with NFPA 30:3-3.6.

Table 3. Typical Point of Use Abatement Installations

PROCESS	PROCESS CHEMISTRY	WATER SCRUBBER	TPU/CATALYTIC OXIDIZERS	TPU WITH WET SCRUBBER	ADSORBERS/ CHEMISORBERS	HOT CHEMICAL BED	END OF PIPE EXHAUST
DRY ETCH	HF, SiF4, NF3, F2, HBr, HCl, SiF6			RECOMMENDED	RECOMMENDED		ACID
ION IMPLANT	BF3, PH3, AsH3, SiH4, GeH4				RECOMMENDED	RECOMMENDED	ACID
FILM	CH4, PH3,B2H6, GeH4, Cl2, NF3, SiF4				RECOMMENDED		ACID
WET ETCH	HCL, H2SO4, HNO3,NH4OH						ACID or BASE
LITHO	F2			RECOMMENDED	RECOMMENDED		ACID
	TMAH, HDMS		RECOMMENDED				VOC
	PGME, PGMEA		RECOMMENDED				VOC
Low K Film Anneal	OZONE				RECOMMENDED		
LPCVD NITRIDE	SiH2Cl2/NH3			RECOMMENDED			ACID
LPCVD POLY/OXIDE	SiF4/FLUORIDE			RECOMMENDED			ACID
PECVD POLY/OXIDE	SiF4/FLUORIDE			RECOMMENDED			ACID
PECVD NITRIDE AND TUNGSTEN	SiH4/ WF6/ H2			RECOMMENDED			ACID
	SiH4/NH3			RECOMMENDED			ACID
CMP	NH4OH, SIO2	RECOMMENDED					

APPENDIX A
HPM Leak Integrity Requirements

1. PURPOSE

1.1 The purpose of this appendix is to set out the leak integrity requirements for all equipment containing HPMs on site. This appendix shall be adhered to whenever new HPM lines are installed; an existing HPM line is altered; and after fittings have been mechanically manipulated within a GC, VMB, CDU, CVMB or a GIB on site.

2. SCOPE

2.1 The scope of this appendix includes verifying the leak integrity of all gas lines, secondary containment gas lines, GCs, VMBs, GIBs, tool GIB, tool interconnecting vacuum lines, tool exhaust/vent lines, liquid chemical lines, secondary containment liquid chemical lines, liquid chemical VMBs, CDU, tool liquid chemical deliver units, tool liquid chemical VMBs liquid drains subjected to any HPMs and, any other equipment used for handling/moving/containing any HPMs used within the site.

3. HPM LEAK INTEGRITY REQUIREMENTS

3.1 All systems for handling/moving/containing gaseous/vaporous HPMs shall be free from any standard leaks greater than $1x10^{-7}$ Pa l/s ($1x10^{-9}$ mBar l/s) via both Helium Leak Detection, as well as Pressure-Decay Leak Detection. Inboard helium leak rate is to be no greater than $1x10^{-6}$ SCC/Second.

3.2 All systems for handling/moving/containing liquid HPMs shall be free from any standard leaks greater than $1x10^{-4}$ Pa l/s ($1x10^{-6}$ mBar l/s) Pressure-Decay Leak Detection.

4. HPM LEAK INTEGRITY TESTING

4.1 All systems for handling/moving/containing gaseous/vaporous HPMs shall pass a 1-hour pressure decay while charged with an inert gas at no less than 125% of the listed operating pressure of the system being tested. Then an Inboard Helium Leak test is to be performed. The minimum level of starting vacuum required on the line is $1x10^{-8}$ Torr. Each fitting is to be sprayed with at least 5 SCC/second of helium for 2 seconds.

4.2 All systems for handling/moving/containing liquid HPMs shall pass Outboard Leak testing with the HPM system charged with an inert gas at least 125% of the intended delivery/process pressure of the liquid HPM. Pressure test is to be a minimum of 4 hours in duration with no loss of pressure.

4.3 The project manager for all installations/alterations must provide a suitable leak checking procedure in writing to NY CREATES EHS for approval prior to performing any HPM Leak Integrity Testing.

- The project manager should verify that any Pressure-Decay Leak Detection procedure considers each of the following:
    - The accuracy of all pressure gauges.
    - The attainable temperature stability of any system tested.
    - The total combined volume of any system tested.
- The project manager should verify that the procedure clearly describes how any isolation valves (to be tested within the system) will be controlled throughout the testing.
- The project manager should conduct a pre-test-controlled leak introduction step suitable to verify that any isolation valves (to be tested within the system) will be appropriately controlled throughout the testing.
- The project manager should verify that any Helium Leak Detection procedure clearly outlines the reasons for substituting Inboard for Outboard or Outboard for Inboard Helium Leak Detection for any system to be tested. They should also verify:
    - There is a reasonable method of marking each fitting/connection after it has been tested.
    - The qualifications of the individual(s) to conduct the testing.
    - The make/model/calibration of the Helium Leak Detector to be used to conduct the testing is included in the procedure.

4.4 Leak checks are required on GCs, VMBs, and GIBs at the completion of maintenance or service and prior to recharging with the process gas as follows:

- All parts of the system that were subjected to the work MUST be tested. The test will consist of either a 12-hour pressure decay or an out-board helium leak test AND a 4-hour pressure decay. The pressure decay and the Helium Leak check will be performed using 125% of the operating pressure of the system.
- The results of each test are to be documented and provided upon request. All data relevant to the test is to be recorded and retained to include but not limited to:
    - Starting pressure.
    - Ending pressure.
    - Duration of test.

- Number of fittings leak checked.
- Number of repairs performed.
- Secondary tests performed.

- Record retention is 5 years.

4.5 Leak checks are not required on CDUs or CVMB repairs. A visual inspection of each fitting that was broken AFTER the system has been recharged with chemicals is required and is to be documented.

- Any leaks that are found will be identified and documented.

5. DUPLICATE RECORDS

5.1 Leak Check Data Sheets (**EHS-00064-F1**) must be completed for each HPM handling/moving/containing system or subsystem of every tool before any HPMs are introduced to the tool.

5.2 All end points of each HPM system/subsystem must be labeled with tags clearly showing:

- The Hex ID of the tool involved.
- The index of the particular system/subsystem.
- The letter designation of the particular end point.
- The date and initials of the individuals conducting the testing.

LEAK CHECK DATA SHEET (SAMPLE)

Sample EHS-00064-F1
LEAK CHECK DATA SHEET

Tool Hex ID: __________
HPM System/subsystem Index: _____
HPM System/subsystem End Points: _____ through _____

PRESSURE-DECAY LEAK DETECTION

	START	STOP	Delta	Pass
Date and Time:			-	-
Pressure Reading:				Yes ☐
Temperature Reading:				Yes ☐

Pre-Test Controlled Leak Completed: Yes ☐ No ☐

HELIUM LEAK DETECTION

Type of Test: Inboard ☐ Outboard ☐

Start Date and Time:	Stop Date and Time:
Starting Background Leak Rate:	Final Background Leak Rate:
Number of Fitting/Connections Tested:	Number of Leaks Repaired:

Pre-Test Controlled Leak Completed: Yes ☐ No ☐

All Tested Fittings and Connections Marked: Yes ☐ No ☐

APPROVAL

Test Performed by: ____________________ Date: __________

Test Approved by: ____________________ Date: __________

EHS Approval by: ____________________ Date: __________