

Standard Operating Procedure (SOP)

This Standard Operating Procedure (SOP) describes basic chemical safety information for toxic gases. Prior to conducting work with toxic gases personnel must obtain approval from their Principal Investigator (PI) and/or Supervisor and attend the appropriate laboratory safety training. The PI must complete the Lab-Specific Use Procedures section and provide their personnel with a copy of this SOP and a copy of the SDS from the manufacturer.

Toxic Gases

Date SOP was written:	
Date SOP was approved by PI/lab supervisor:	
Principal Investigator:	
Principal Investigator Signature:	

Type of SOP: Process Hazardous Chemical Hazardous Class

Purpose



The purpose of this standard operating procedure is to acquaint you with the proper and safe handling, use, storage, and disposal of toxic gases.

Properties & Hazards

General Hazards:

Chemicals in this band present hazards based on their toxicity and the pressurized nature of their storage/use. Chemicals in this band may also have flammable, oxidizing, and corrosive properties, specific storage and handling guidelines apply to each hazard class.

The GHS and Cal/OSHA definition of the band is described in the table below:

GHS Pictogram	UCI Hazard Level	GHS Category	GHS H-Code	Cal/OSHA Definitions
	Highly Hazardous	Acute Toxicity (Cat. 1, 2)	H330	Highly Toxic
	Generally Hazardous	Acute Toxicity (Cat. 3, 4, 5)	H331, H332, H333	Toxic
	Generally Hazardous	Gases Under Pressure	H280, H281	Compressed Gas

- Toxic gases are grouped by GHS health hazards into four classes based on the lethal concentration to 50% of test animals (rats) of each gas (LC50).
 - Class I: ≤ 200 ppm
 - Class II: >200 ppm, ≤ 2000 ppm
 - Class III: >2000 ppm, ≤ 5000 ppm
 - Class IV: > 5000 ppm
- Corrosive gases are considered highly hazardous under the Corrosives & Irritants hazard band.
- Flammable gases are considered highly hazardous under the Flammables hazard band.
- Oxidizing gases are considered highly hazardous under the Oxidizers hazard band.

- Cryogenic liquids are described in further detail in the Cryogenic Liquid SOP.

Determine which hazard class(es) your compressed gas belongs to by referring to the SDS and the listing of hazard classifications for various compressed gases in Appendix B. Ensure that all of the UCI safety requirements outlined in this SOP, the UCI Toxic Gas Program, the UCI Compressed Gas Program, and Appendices A – C are followed.

Personal Protective Equipment (PPE)

Skin and Body Protection:

Long pants (or equivalent) completely covering legs, closed toed shoes, and a traditional lab coat or flame resistant Nomex® lab coat when working with flammables.

Hand Protection:

Nitrile or neoprene gloves are typically adequate for minor splashes. Thicker gloves should be used for longer operations, larger quantities, or direct contact. Consult the SDS, and/or the lab specific use section to determine whether the material or process requires alternative hand protection.

Eye Protection:

ANSI Z87.1-compliant safety glasses or safety goggles if a splash hazard is present.

Administrative Controls

- Never work alone with toxic gases. Inform all other personnel in the laboratory before working with these chemicals.
- Review the Safety Data Sheets (SDSs) for all chemicals used in the experiment. Online SDSs can be accessed at <https://www.ehs.uci.edu/sds/index.php>.
- All personnel working with compressed gases must have completed the “Compressed Gas Safety” training through EHS.
- Before working with toxic gases, all personnel should read and follow the compressed gas program (https://www.ehs.uci.edu/programs/_pdf/safety/compressed-gases-safety-program.pdf, and <https://ehs.uci.edu/safety/pdfs/compressed-gas-reference-guide.pdf>) and the toxic gas program, https://www.ehs.uci.edu/training/tango/_pdf/ToxicGasFactSheet.pdf.
- Toxic gases must be used in a “designated area” within the laboratory. A designated area may be the entire laboratory, an area of a laboratory, or a device such as a laboratory hood.
- Gas monitors must be properly maintained, calibrated, and replaced according to the manufacturer’s recommendations.
- Only order the amount of compressed gases you will need for planned or foreseeable experiments.

Engineering Controls

- All toxic gas cylinders/containers must be used and stored in a designated area.
- Toxic gas cylinders must be double chained, stored in compliance with Cal/OSHA and NFPA code requirements, and stored in an exhausted enclosure (e.g. fume hood), cabinet, or separated ventilation room. Ventilation monitoring is needed for these storage locations.

- Reaction vessels or chambers must be located inside of an exhausted enclosure (e.g. fume hood).
- All regulators, valves, and lines must be chemically compatible, the proper size/type, and leak tested before use.
- Purge vents must be connected to an exhaust system that discharges to a safe location.

Special Storage and Handling Requirements

Additional storage and handling requirements are outlined in Appendix C. Ensure that all of the safety requirements outlined in the SDS, this SOP, the UCI Toxic Gas Program, the UCI Compressed Gas Program, and Appendices A – C are followed.

Storage:

- All toxic gas cylinders/containers must be upright, double chained, stored in compliance with Cal/OSHA and NFPA code requirements, and stored in a designated area. All toxic gas cylinders/containers and storage locations must be clearly labeled.
- Store full and empty cylinders separately to avoid confusion and label cylinders with the appropriate full/in use/empty tag.
- Organize gas cylinders so that they are used in the order they are received.
- Store in a cool, dry, well-ventilated area (e.g. exhausted enclosure, cabinet, or ventilation room).
- Remove regulators from gas cylinders and replace with the protection cap when not in use.
- Do not keep non-corrosive gases longer than 5 years beyond their last hydrostatic test date (typically stamped just below the neck of the cylinder) unless otherwise regulated.
- Immediately return all cylinders that appear unsafe or show signs of corrosion, dents, dings, pitting, bulging, etc.
- Review your gas inventory monthly, keep quantities to a minimum.
- Purchase the lowest concentration mixture that will accomplish the desired experiment.
- Separate incompatibles, for example separate oxidizers (e.g. oxygen) and from flammables (e.g. hydrogen) by at least 20 ft.
- Do not allow grease or oil to come into contact with compressed gases, regulators, or tubing.
- Do not store cylinders next to doors, in corridors, or in locations that could possible obstruct emergency exit from the building.
- Some of the additional requirements for flammable, oxidizing, and corrosive gases are described below:
 - **Flammable gases**
 - Never store near ignition, heat sources, and unprotected electrical connections.
 - Storage cabinets must be equipped with fire sprinklers.
 - **Oxidizing gases**
 - Never store near flammable materials, combustible materials, unprotected electrical connections, ignition sources, and heat sources.
 - **Corrosive gases**
 - Never store corrosive gases (e.g. ammonia, chlorine) longer than 6 months, cylinders containing corrosive gases degrade over time.

Handling:

- Know the hazard classification of the particular gases you are working with and take all of the necessary safety precautions.

- Label both the cylinder and the gas line with the name of the gas, do not depend on color codes.
- Work in a well-ventilated area, handle toxic gases in a fume hood. Cylinders and reaction vessels must be located inside of an exhausted enclosure.
- Always leak test the system prior to use and/or toxic gas introduction.
- All regulators, valves, and lines must be chemically compatible, the proper size, and the proper type. Never use an adaptor.
- Never permit a flame or spark to come into contact with any part of a compressed gas cylinder.
- Use a trap or suitable check valve when discharging gas into a liquid to prevent the liquid from getting back into the cylinder or regulator.
- Use only small cylinders of toxic gases whenever possible. Only order the amount of toxic gases you will need for planned or foreseeable experiments.
- Slowly introduce the gas to the regulator, never allow the gas to suddenly enter the regulator.
- If a leak is detected, immediately close the cylinder valve. Never try to stop a leak between the cylinder and regulator by tightening the union nut with the cylinder valve open.
- Never strike an electric arc on the cylinder.
- Use caution if a flow does not immediately start when a valve is opened slightly – there could be a plug or clog.
- Avoid using lecture bottles when possible.
- Some of the additional requires for flammable, oxidizing, and corrosive gases are described below:
 - **Flammable gases**
 - Use flow restrictors to prevent a sudden large unexpected release.
 - A gas detection system may be required.
 - **Oxidizing gases**
 - Clean regulators and tubing to remove oil and reducing agents.
 - **Corrosive gases**
 - Inspect cylinder valves periodically for corrosion.

Transportation:

- Leave the valve protection cap in place at all times during transportation and do not remove the cap until the gas cylinder is ready for use.
- Use a hand truck or other suitable device to transport cylinders, even for short distances. Secure the cylinder to the transportation cart with a chain or strap. Do not roll, drag, or slide cylinders. Do not lift cylinders by cylinder caps.
- Never store or use cylinders on transportation carts.
- Never leave a cylinder on a transportation cart unattended. Always move cylinders to a secure location as soon as possible.

Spill, Accident, and First Aid Procedures

Spill/Release:

Immediately notify others in the area. Evacuate and prevent access to the location where the spill/release occurred. Notify supervisor and EHS at x4-6200 immediately. Do not try to clean up the spill/release.

Skin or Eye Contact:

Move to fresh air. Remove contaminated clothing or contact lenses and flush the affected area with water for at least 15 minutes. Obtain medical attention immediately.

Inhalation:

Move to fresh air. Obtain medical attention immediately. (The poison control center, (800) 222-1222, is available 24 hours every day).

Waste Disposal Procedure

Disposal:

- Hazardous waste must be transferred to EHS for disposal within 6 months of being generated.
- Hazardous Waste Disposal
 - Send a text message [Text a pick up](#) to hwp@uci.edu, EHS will pick up your waste within 1-3 days
 - Or visit <https://ehs.uci.edu/enviro/haz-waste/>

Additional Information

- For additional information about toxic gases, review the:
- UCI Compressed Gas Program, https://www.ehs.uci.edu/programs/_pdf/safety/compressed-gases-safety-program.pdf
- TANGO Compressed Gas Handout, <https://ehs.uci.edu/safety/pdfs/compressed-gas-reference-guide.pdf>
- UCI Toxic Gas FactSheet, https://www.ehs.uci.edu/training/tango/_pdf/ToxicGasFactSheet.pdf

APPENDIX A: **Lab-Specific Use Procedures**

The following procedures describe how the subject chemicals are used in this laboratory beyond the practices described above.

Please see the General Information for ***Hazardous Materials Standard Operating Procedure*** for specific instructions on writing lab-specific use produces.

This section must describe lab-specific procedures to address the safe use of all highly hazardous chemicals from this band in use in the laboratory. These procedures may be organized around specific chemicals, specific tasks or the band as a whole.

APPENDIX B: UCI Hazardous Gas Classification Table

Gas and Formula	CAS and UN or NA No.	UBC/CFC Class ¹	UCI Class ²	IDLH ³	LC50 ⁴	PEL ⁵
Ammonia – NH ₃	7664–41–7, UN1005	Corrosive ^{6,7} , flammable	III	300 ppm	4000 ppm	50 ppm
Arsine – AsH ₃	7784–42–1, UN2188	Highly toxic, flammable	I	3 ppm	20 ppm	0.05 ppm
Boron Tribromide – BBr ₃	10294–33–4, UN2692	Toxic	II	50 ppm	380 ppm	1 ppm ^{5(C)}
Boron Trichloride – BCl ₃	10294–34–5, UN1741	Corrosive ⁶	III	25 ppm ⁸	2541 ppm	5 ppm
Boron Trifluoride – BF ₃	7637–07–2, UN1008	Toxic	II	25 ppm	806 ppm	1 ppm ^{5(C)}
Bromine – Br ₂	7726–95–6, UN1744	Highly toxic, corrosive, oxidizer	I	3 ppm	113 ppm	0.1 ppm
Carbon Monoxide – CO	630–08–0, UN1016	Flammable ⁶	III	1200 ppm	3760 ppm	50 ppm
Chlorine – Cl ₂	7782–50–5, UN1017	Toxic, corrosive, oxidizer	II	10 ppm	293 ppm	1 ppm ^{5(C)}
Chlorine Dioxide – ClO ₂	10049–04–4, NA9191	Toxic, oxidizer	II	5 ppm	250 ppm	0.1 ppm
Chlorine Trifluoride – ClF ₃	7790–91–2, UN1749	Toxic, oxidizer	II	20 ppm	299 ppm	0.1 ppm ^{5(C)}
Diborane – B ₂ H ₆	19278–45–7, UN1911	Highly toxic, flammable	I	15 ppm	80 ppm	0.1 ppm
Dichlorosilane – SiH ₂ Cl ₂ (HCl)	4109–96–0, UN2189	Toxic, corrosive, flammable	II	50 ppm	314 ppm	5 ppm ^{5(C)}
Ethylene Oxide – C ₂ H ₄ O	75–21–8, UN1040	Flammable ⁶	III	800 ppm	4350 ppm	1 ppm
Fluorine – F ₂	7782–41–4, UN1045	Highly toxic, oxidizer	I	25 ppm	185 ppm	0.1 ppm
Germane – GeH ₄	7782–65–2, UN2192	Toxic, flammable	II	6 ppm ⁸	622 ppm	0.2 ppm ⁹
Hydrogen Bromide – HBr	10035–10–6, UN1048	Corrosive ⁶	III	30 ppm	2860 ppm	3 ppm
Hydrogen Chloride – HCl	7647–01–0, UN1050	Corrosive ⁶	III	50 ppm	2810 ppm	5 ppm ^{5(C)}
Hydrogen Cyanide – HCN	74–90–8, UN1051	Highly toxic, flammable	I	50 ppm	40 ppm	10 ppm
Hydrogen Fluoride – HF	7664–39–3, UN1052	Toxic	II	30 ppm	1300 ppm	3 ppm
Hydrogen Selenide – H ₂ Se	7783–07–5, UN2202	Highly toxic, flammable	I	1 ppm	2 ppm	0.05 ppm

Gas and Formula	CAS and UN or NA No.	UBC/CFC Class ¹	UCI Class ²	IDLH ³	LC50 ⁴	PEL ⁵
Hydrogen Sulfide – H ₂ S	7783–06–4, UN1053	Toxic, flammable	II	100 ppm	712 ppm	20 ppm
Methyl Bromide – CH ₃ Br	74–83–9, UN1062	Toxic, flammable	II	250 ppm	1007 ppm	20 ppm ^{5(C)}
Methylisocyanate – CH ₃ NCO	624–83–9, UN2480	Highly toxic, flammable	I	3 ppm	22 ppm	0.02 ppm
Methyl Mercaptan – CH ₃ SH	74–93–1, UN1064	Toxic, flammable	II	150 ppm	1350 ppm	10 ppm ^{5(C)}
Nickel Carbonyl – Ni(CO) ₄	13463–39–3, UN1259	Highly toxic, flammable	I	2 ppm	18 ppm	0.001 ppm
Nitric Oxide – NO	10102–43–9, UN1660	Highly toxic, oxidizer	I	100 ppm	115 ppm	25 ppm
Nitrogen Dioxide – NO ₂	10102–44–0, UN1067	Highly toxic, oxidizer	I	20 ppm	115 ppm	5 ppm ^{5(C)}
Phosgene – COCl ₂	75–44–5, UN1076	Highly toxic	I	2 ppm	5 ppm	0.1 ppm
Phosphine – PH ₃	7803–51–2, UN2199	Highly toxic, pyrophoric	I	50 ppm	20 ppm	0.3 ppm
Phosphorus Oxychloride – POCl ₃	10025–87–3, UN1810	Highly toxic	I	0.96 ppm ⁸	96 ppm	0.1 ppm ⁹
Phosphorus Pentafluoride – PF ₅	7647–19–0, UN2198	Toxic, oxidizer	II	2.6 ppm ⁸	260 ppm	3 ppm
Phosphorus Trichloride – PCl ₃	7719–12–2, UN1809	Toxic, oxidizer	II	25 ppm	208 ppm	0.5 ppm
Selenium Hexafluoride – SeF ₆	7783–79–1, UN2194	Highly toxic	I	2 ppm	50 ppm	0.05 ppm (as Se)
Silicon Tetrachloride – SiCl ₄ (HCl)	10026–04–7, UN1818	Toxic, corrosive	II	50 ppm	750 ppm	5 ppm ^{5(C)}
Silicon Tetrafluoride – SiF ₄ (HF)	7783–61–1, UN1859	Toxic	II	30 ppm	450 ppm	0.1 ppm
Stibine – SbH ₃	7803–52–3, UN2676	Highly toxic, flammable	I	5 ppm	20 ppm	0.1 ppm
Sulfur Dioxide – SO ₂	7446–09–5, UN1079	Corrosive ⁶	III	100 ppm	2520 ppm	5 ppm
Sulfuryl Fluoride – SO ₂ F ₂	2699–79–8, UN2191	Corrosive ⁶	III	200 ppm	3020 ppm	5 ppm
Tellurium Hexafluoride – TeF ₆	7783–80–4, UN2195	Highly toxic	I	1 ppm	25 ppm	0.02 ppm (as Te)
Titanium Tetrachloride – TiCl ₄	7550–45–0, UN1838	Highly toxic, corrosive	I	1.3 ppm	119 ppm	—
Tungsten Hexafluoride – WF ₆ (HF)	7783–82–6, UN2196	Toxic, corrosive	II	30 ppm	217 ppm	0.1 ppm

(Table adapted from Santa Clara County's Hazardous Gas Table.)

References

1. UBC/ CFC Class:
 - a. UBC (Uniform Building Code)
 - b. CFC (California Fire Code)
 - c. Class as defined in CFC:
 - i. Health hazards per Article 2
 - ii. Highly toxic = < 200 LC50
 - iii. Toxic = 201–2000 LC50
 - d. Physical hazards per CFC Standard 7903.
2. UCSD Hazard Class defined as:
 - a. Class I = < 200 LC50
 - b. Class II = 201–2000 LC50
 - c. Class III = 2001–5000 LC50
3. IDLH (Immediately Dangerous to Life and Health) values published in 1994 by the National Institute for Occupational Safety and Health (NIOSH).
4. LC50 data: Lowest reported value, 1 hour adjusted, taken from Dept. of Transportation, Compressed Gas Association, Registry of Toxic Effects of Chemical Substances.
5. PEL (Permissible Exposure Limit) values published by Occupational Safety & Health Administration (OSHA), 29 Code of Federal Regulations, Part 1910.1000, Table Z–1, 7/1/95. OSHA values used if available; otherwise, Threshold Limit Values (TLV) from American Conference of Governmental Industrial Hygienists (ACGIH) or California Division of Occupational Safety and Health (Cal/OSHA) values used.
(C) = TLV-ceiling limit, an exposure limit not to be exceeded under any circumstances.
6. Moderately toxic as adopted by the cities of San Jose, Santa Clara, and Milpitas: LC50 = 2,000–5000.
7. When used as a refrigerant, Uniform Building Code Class does not apply.
8. IDLH determined by 0.01 of LC50.
9. Cal/OSHA PEL, Title 8, Section 5155, 9/1/95.

APPENDIX C: UCI Safety Requirements for Compressed & Hazardous Gases

Follow these safety requirements for the use of compressed gases according to the hazard class. Check Appendix A to determine the hazard class of your material. Then follow the appropriate usage requirements indicated in the table and discussed in greater detail below.

Requirements	Class IV	Lab Use Exemption	Class III	Class II	Class I
1. Exhausted enclosures (gas cabinets or fume hoods)		X	¹ C	X	X
2. Treatment to ½ IDLH at atmosphere		X	X	X	X
3. Leak check (of installed system)		X	X	X	X
4. Emergency response plan, team, and drills		X	X	X	X
5. Flow-limiting device or flow-restricting orifice		X	¹ C	X	X
6. Use in sprinklered spaces		X	X	X	X
7. Documented annual maintenance			X	X	X
8. Compatible piping			X	X	X
9. Purge system			¹ C	X	X
10. Detector system		X (class I)	¹ C	¹ C	X
11. Emergency alarms (and explanatory signs)		X (class I)	¹ C	X	X
12. Welded, compatible piping				X	X
13. Local shut-off				X	X
14. Interlocks				X	X
15. Emergency power (alarm, detector, ventilation)		X (class I)		X	X
16. Monitored secondary containment					¹ C
17. Auto shut-off (manual or detector triggered)				X	X
18. Exhaust flow alarm		X (class I)			X

¹C = These systems are conditional and will be determined by the EHS Chemical Safety Officer or EHS Safety Engineer.

Exceptions

Requirements are relaxed for small quantities and short-term usage as follows:

1. Less than 340 standard cubic feet (SCF) of class II and class III materials used for less than 30 consecutive days require:
 - a. Initial consultation with EHS Chemical Hygiene Officer or EHS Safety Engineer
 - b. Basic gas safety, including an emergency response plan and drills
 - c. No lecture bottles
 - d. Flow-restricting orifice (FRO)
 - e. Exhausted enclosure adequate to dilute full release to 1/2 IDLH (Immediately Dangerous to Life and Health)
 - f. Leak check procedures for receiving cylinders and for manifolds
 - g. Storage and use in a sprinklered space
2. Less than 20 SCF of class I materials used for less than 30 consecutive days require above items, plus:
 - a. Gas and exhaust system flow-detector systems connected to alarm system
 - b. Emergency power for detectors and alarms

3. Requirements above may be relaxed for quantities less than 2 pounds; no single cylinder more than 1 pound (1/4 pound for class I). Quantities over threshold levels raise the level of classification.

Requirements Details

1. Exhausted enclosures (gas cabinets or fume hoods)

- a. All class I and II gases must be kept in an exhausted enclosure at all times. Class III gases, flammable gases, and oxidizing gases are conditional depending on the application and the specific gas in question. Gas cabinets must be equipped with automatic fire sprinkler system protection, and must be constructed and ventilated according to code requirements. Exhausted enclosures must:
 - i. Operate at negative pressure in relation to the surrounding area
 - ii. Be provided with self-closing limited access ports or non-combustible windows to give access to equipment controls — the average face velocity at the face of the access ports or windows shall not be less than 200 feet per minute (1.01 m/s) with a minimum of 150 feet per minute (0.76 m/s) at any 1 point of the access port or window
 - iii. Connect to an approved exhaust system
 - iv. Be provided with self-closing doors
 - v. Be constructed of not less than 0.097 inch (2.46 mm) (12 gage) steel
 - vi. Not contain more than 3 cylinders in a single gas cabinet
 1. Exception: Cabinets containing cylinders not exceeding 1 pound (0.4536 kg) net contents each shall not exceed 100 cylinders.
 - vii. Be seismically restrained
 - viii. Be certified annually by EHS for proper air flow
- b. Gas cabinet references:
 - i. [Safety Equipment Corp.](http://www.safetyequipmentcorp.com/) (http://www.safetyequipmentcorp.com/)
 - ii. [Matheson Tri-Gas](https://store.mathesongas.com/gas-delivery-systems/) (https://store.mathesongas.com/gas-delivery-systems/)
 - iii. [Thermo Fisher Scientific Inc.](http://www.thermofisher.com/global/en/home.asp) (http://www.thermofisher.com/global/en/home.asp)

2. Treatment to 1/2 IDLH (Immediately Dangerous to Life and Health) at atmosphere

- a. Treatment systems must be designed to reduce the maximum allowable discharge concentration of the gas to 1/2 IDLH at the point of discharge to the atmosphere. When more than 1 gas is emitted to the treatment system, the treatment system must be designed to handle the worst-case release based on the release rate, the quantity, and the IDLH for all the gases stored or used.

3. Leak check (of installed system)

- a. Gas systems must be leak tested at the following intervals:
 - i. Upon receipt
 - ii. At installation
 - iii. Periodically during operation
 - iv. At disconnect / shipping
 - v. It is critical that these gases also be leak tested prior to removal from their exhausted enclosures and subsequent to transport, or if you have reason to believe that the system has been compromised.

4. Emergency response plan, team, and drills

- a. All laboratories must have an emergency response plan that addresses the use and/or storage of compressed gases.

5. Flow-limiting device or flow-restricting orifice

- a. Use a flow-limiting device to restrict hazardous gas flow rates to just over maximum flow required (e.g., flow restricting orifice). These devices must be installed immediately downstream of each gas cylinder.
- b. For small scale experiments, such as fume hood use, a needle valve is sufficient.
- c. For large cylinders, a flow restricting orifice must be installed by the gas supplier in the cylinder valve or installed in the gas purge panel.
- d. Reference guide:
 - i. [Matheson Tri-Gas](https://store.mathesongas.com/gas-delivery-systems/) (https://store.mathesongas.com/gas-delivery-systems/)

6. Use in sprinkled spaces

- a. Sprinkler protection is required in all spaces unless otherwise approved.

7. Documented annual maintenance

- a. Keep records of all maintenance associated with gas systems (e.g., gas detection calibration and/ or repairs).

8. Compatible piping

- a. Piping, tubes, valves, fittings, and related components must be:
 - i. Designed and fabricated from materials compatible with the material to be contained
 - ii. Of adequate strength and durability to withstand the pressure, structural and seismic stress, and exposure to which they are subject
 - iii. Identified in accordance with nationally recognized standards to indicate the material conveyed

9. Purge system

- a. The ability to purge the area between the cylinder valve and the regulator with an inert gas prior to maintenance or cylinder change out is required. Inert gases used for this purpose must be used solely for this purpose and no other operation.

10. Detector system

- a. A continuous gas-detection system is required to detect the presence of gas at or below the permissible exposure limit or ceiling limit. The detection system must:
 - i. Initiate a local alarm and transmit a signal to a constantly attended control station (exceptions may apply)
 - ii. Be capable of monitoring the room or area in which the gas is stored at or below the permissible exposure limit or ceiling limit and the discharge from the treatment system at or below 1/2 IDLH (Immediately Dangerous to Life and Health) limit
 - iii. The alarm must be both inside and outside the storage area. The audible alarm must be distinct from all other alarms.
 - iv. Note: Exceptions to detection systems may exist for class II gases.

11. Emergency alarms (and explanatory signs)

- a. Alarm system must be posted with information on:
 - i. What the alarm states mean
 - ii. What actions to take
 - iii. Who to contact

12. Welded, compatible piping

- a. Piping and tubing must:
 - i. Have welded or brazed connections throughout unless an exhausted enclosure is provided
 - ii. Not be located in any portion of a corridor unless otherwise approved by the UCI Fire Marshal
 - iii. See the section on Compatible Piping for addition information

13. Local shut-off

- a. Personnel must be able to shut the system off at the source.

14. Interlocks

- a. An automatic shutdown of gas flow must be initiated when any of these conditions occur:
 - i. Hazardous condition is detected
 - ii. Seismic disturbance
 - iii. Loss of power – see Emergency Power section for more information
 - iv. Excess-flow-triggered shut-off – Where gases are carried in pressurized piping above 15 psig (103.4 kPa), excess flow control must be provided
 - v. Loss of vacuum
 - vi. Loss of cooling
 - vii. Loss of ventilation

15. Emergency power (alarm, detector, ventilation)

- a. Emergency power must be provided for these systems:
 - i. Exhaust ventilation (including the power supply for treatment systems)
 - ii. Gas cabinet ventilation

- iii. Exhausted enclosure ventilation
- iv. Gas-detection
- v. Emergency alarm

16. Monitored secondary containment

- a. Any secondary containment system must have a detection system.

17. Auto shut-off (manual or detector triggered)

- a. When a short-term hazard condition is detected, the gas detection system must automatically close the shut-off valve at the source on gas supply piping and tubing related to the system being monitored for which gas is detected.

18. Exhaust flow alarm

- a. Should ventilation become inadequate, an audible and visual alarm must be available.

Documentation of Training

Prior to conducting any work with toxic gases, designated personnel must provide training to their laboratory personnel specific to the hazards and procedures involved in working with these substances.

I have read and understand the content of this SOP:

Name	Signature	Date