NJIT New Jersey Institute of Technology

GASES UNDER PRESSURE

(Excluding Toxic and Highly Toxics Gases)

STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☐ Hazard Class

Department: _____ **Building:** _____ **Room #:**_____

Principal Investigator: _____ **Phone #:**_____

Prepared By: _____ **Email:** _____ **Date:** _____

1. HAZARD OVERVIEW

The purpose of this standard operating procedure is to acquaint you with the proper and safe handling, use, storage and disposal of compressed gases. However, gases that are considered toxic or highly toxic are **excluded** from this SOP.

Common toxic and highly toxic gases are listed in the Appendix of this document. Given their high hazard and special regulations that apply to their use, these materials should have their own gas-specific SOP. In some cases, the volume or concentration of toxic/highly toxic gases may allow less rigorous control measures. Contact the EHS Department for assistance.

This SOP would typically apply to inert gases like nitrogen, argon and helium; flammable gases like hydrogen, methane, and propane; and Oxygen (oxidizer). Other gases like fluorine and chlorine are also strong oxidizers, but because of their high toxicity should have their own SOP.

Chemicals in this category present hazards based on one or more of these characteristics:

- The pressurized nature of their storage and use
- Flammability
- Oxidizing ability
- High toxicity *(As stated above these do not fall under this SOP, but should be addressed separately given their extreme hazard.)*

All chemicals in this band are considered generally hazardous and the band is general

- gases which are contained in a receptacle at a pressure of 29 psi (200 kPa) or more at 20 ºC
- gases which are liquefied or liquefied and refrigerated

2. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Appropriate PPE should be worn at all times when handling chemical products. A hazard assessment will indicate the PPE requirement. Please refer to the NJIT Chemical Hygiene Guide and Hazard Assessment Form to determine the proper PPE for handling corrosive materials.

Reference: University of California, Santa Barbara - Environmental Health & Safety

3. ENGINEERING/VENTILATION CONTROLS

Basic pressurized gas control measures are noted here. For further information, see Sec. 7D of Prudent Practices in the Laboratory by the National Research Council. Gas vendors are another good source of information on gas equipment and handling.

- In general, it is preferable to perform all work with hazardous chemicals in a fume hood. Sash height should be kept as low as possible to avoid the escape of vapors, gases and particulates.
- Supplemental equipment such as blast shields should be used when working with chemicals or processes that may result in explosions or pressure releases.
- Consider the use of a glove box, toxic gas cabinet, or other local exhaust in order to further contain hazards as appropriate. Gas cabinets may be required for some toxic gas applications.

Please review the NJIT Chemical Hygiene Guide and the Safe Chemical Fume Hood Use Guide for information on the proper use of a chemical fume hood and criteria for implementing engineering controls.

☐ Chemical Fume Hood ☐ Glovebox ☐ Biological Safety Cabinet ☐ Other _____

Room Location of Unit(s): _____

4. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

a. Storage Areas

- Store full and empty compressed gas cylinders separately to avoid confusion. Serious back flow can occur when an empty cylinder is attached to a pressurized system.
- Store in a cool, dry, and well-ventilated area.
  - Cool areas minimize pressure increases that can result from heat or direct sunlight.
  - Dryness deters rust and corrosion.
  - Ventilation is essential in case of leaks.
  - Compressed gas cylinders should not be stored in environmental rooms (i.e., refrigerated cold rooms or warm rooms). These rooms are not well ventilated and could pose a serious safety concern should a cylinder fail.
- Arrange storage facilities to permit inventory rotation, using cylinders in order as received from the supplier.
- Do not store cylinders next to doors or in corridors where they could possibly obstruct emergency egress from the building.
- Designate an area to store empty cylinders for return to the supplier. An area on or adjacent to your building's loading dock is suitable.
- Separate oxidizers or other incompatibles (e.g., oxygen) from flammables by at least 20 feet, or by a non-combustible wall with a fire rating of at least one (1) hour.

Reference: University of California, Santa Barbara - Environmental Health & Safety

b. Storage Guidelines

- Restrain cylinders as follows:
  - Store cylinders upright and secure them to a substantial, fixed surface with restraints made of non-combustible material, preferably a chain.
  - Position the restraint approximately 2/3 of the height of the cylinder from the floor to prevent tipping.
- Properly label the cylinders and storage area.
- Cap cylinders when not in use.
- Store cylinders away from non-compatibles.
- Store empty cylinders separately from full cylinders.
- Do not keep non-corrosive gases longer than 5 years from the last hydrostatic test date (usually stamped just below the neck of the cylinder) unless otherwise regulated.
- Return all cylinders to the vendor that appear unsafe or show signs of corrosion, dents, dings, pitting, bulging, etc.
- Review your cylinder inventory regularly.
  - Return cylinders to the vendor if they're no longer being used. This removes potential hazards and saves on cylinder rental fees (cylinders are typically rented or leased, rather than purchased) and possible reconditioning fees.
  - NOTE: Some vendors charge a reconditioning fee on each cylinder that is not returned within 2 years. This fee may be significant in relation to the actual cost of the gas.
- In addition to standard storage requirements listed above, employ special precautions for cylinders containing flammable, oxidizing, or corrosive gases (empty or full) as described below:

  i. **Flammable gases**
     - Separate from cylinders containing oxidizing gases by a minimum distance of 20 feet or by a noncombustible partition with a rating of one (1) hour.
     - Never store flammable gas near ignition or heat sources, or unprotected electrical connections.
     - Keep quantities to a minimum. There may be circumstances where using a pure flammable gas may pose unacceptable risks. It may be necessary to purchase a reduced concentration mixture (e.g., 1% hydrogen and 99% argon).
     - If you need large volumes (more than 1 large cylinder), contact the EHS Chemical Hygiene Officer for guidance.

  ii. **Oxidizing gases**
     - **Do not** permit oil or grease to come in contact with compressed oxidizing gases – explosions may occur!

Reference: University of California, Santa Barbara - Environmental Health & Safety

- Separate oxidizers from cylinders containing flammable gases by a minimum distance of 20 feet or by a noncombustible partition with a fire rating of at least one (1) hour.
- Never store oxidizers near flammable solvents, combustible materials, unprotected electrical connections, or ignition or heat sources.

iii. **Corrosive gases**

- Never store lecture bottles of corrosives longer than 6 months and cylinders more than 2 years. (e.g., ammonia, hydrogen chloride, chlorine, and methylamine) Cylinders containing corrosives degrade over time.

c. Operational Guidelines

- Know the hazard classification of particular gases you are working with and specific safety requirements as discussed above.
- Label both the cylinder and gas line with the name of the gas. Do not depend on color codes.
- Work in a well-ventilated area when using compressed gases.
- Use the correct regulator. Ensure that each gas in use has its own dedicated regulator. **Never use adapters.**
- Never permit a flame or spark to come in contact with any part of a compressed gas cylinder. Have flashback protectors installed on cylinders of flammable gases, such as oxy-acetylene torch units.
- Use a trap or suitable check valve when discharging gas into a liquid to prevent liquid from getting back into the cylinder or regulator.
- Lecture bottles use universal threads and valves, and some of them are interchangeable. This increases the risk of accidentally mixing incompatible materials.
- In addition to standard operational requirements listed above, employ special precautions for cylinders containing flammable, oxidizing, or corrosive gases (empty or full) as described below.

i. **Flammable gases**

- Use flow restrictors to prevent a sudden large unexpected release.
- Detection systems may be required.

ii. **Oxidizing gases**

- Diligently clean regulators and tubing used with oxidizing gases to remove oil and other reducing agents.

iii. **Corrosive gases**

- Inspect cylinder valves periodically for corrosion.
- If a cylinder or valve is noticeably corroded, contact the gas vendor and follow their instructions.

- Alert the vendor to any damage that might impair the integrity of the cylinder before the cylinder is returned.
- Use caution if flow does not immediately start when a valve is opened slightly — there could be a plug in the valve.

d. Transporting Gas Cylinders

- Leave the valve protection cap in place until the cylinder has been secured against a wall or bench or placed in a cylinder stand, and is ready for use.
- Use a hand truck or other suitable device to transport cylinders, even for short distances. Secure the cylinder to the hand truck with a chain or strap.
  - Do not roll, drag, or slide containers.
  - Do not lift cylinders by cylinder caps.
- Before returning empty cylinders to the supplier:
  - Close the valve. Leave some positive pressure in the cylinder.
  - Replace any valve outlet and protective caps originally shipped with the cylinder.
  - Mark or label the cylinder "empty" and store it in a designated area for the supplier.
- Move any cylinders that have been left unattended into a secure location as soon as possible.

5. INCIDENTS AND ACCIDENTS

In case of cylinder leaks that can't be stopped by tightening the valve gland or packing nut, do the following:

- For hazardous gases:
  - Leave the room, closing the door behind you.
  - Secure the room to prevent entry.
  - Sound the fire alarm, unless the gas leak is relatively slow and contained within a gas cabinet, or fume hood.
  - Call for emergency assistance. Dial 9-1-1, preferably from a cell phone. Tell the dispatcher the location is NJIT, the building and room number, and the name of the gas being released.
- For non-hazardous gases:
  - Close the leaking valve.
  - If it is still leaking, replace the cylinder cap and notify NJIT Public Safety requesting EHS assistance.

Laboratory personnel are to report all occupational injuries or illnesses to Faculty/PI as soon as practical. The Faculty/PI and laboratory personnel must submit the required paperwork to NJIT EHS Department. See the the Emergency Response Guidelines posted in the laboratory or Emergency Procedures section of the NJIT CHG for proper procedures involving an injury, exposure, fire, or release/spill of a hazardous material.

In the event of an emergency, DIAL 9-1-1 to activate emergency response personnel.

6. SPILL AND DECONTAMINATION

Wear proper PPE; decontaminate equipment and bench tops using sodium bicarbonate and water, or other appropriate decontamination/cleaning solution. Dispose of all used contaminated disposables as hazardous waste following Waste Disposal Section of the NJIT CHG.

Additional Spill / Decontamination Requirements:

7. WASTE DISPOSAL

Follow the practices and procedures in accordance with the NJIT Laboratory Waste Management Program to properly dispose of waste.

Additional Waste Disposal Requirements:

8. PRIOR APPROVAL/REVIEW

9. DESIGNATED USE AREA

Designated Use Area Location(s): _____

10. SAFETY DATA SHEETS

Location of SDS: _____

11. LAB-SPECIFIC INFORMATION (required) *(Examples of appropriate content)*

Appendix -- Hazardous Gas Classification Table

Gas and Formula	CAS and UN or NA No.	UBC Class[1]	IDLH[2]	LC50[3]	PEL[4]
Ammonia – NH_3	7664–41–7, UN1005	Corrosive[5], flammable	300 ppm	4000 ppm	50 ppm
Arsine – AsH_3	7784–42–1, UN2188	Highly toxic, flammable	3 ppm	20 ppm	0.05 ppm
Boron Tribromide – Bbr_3	10294–33–4, UN2692	Toxic	50 ppm	380 ppm	1 ppm[4(C)]
Boron Trichloride – BCl_3	10294–34–5, UN1741	Corrosive[5]	25 ppm[7]	2541 ppm	5 ppm
Boron Trifluoride – BF_3	7637–07–2, UN1008	Toxic	25 ppm	806 ppm	1 ppm[4(C)]
Bromine – Br_2	7726–95–6, UN1744	Highly toxic, corrosive, oxidizer	3 ppm	113 ppm	0.1 ppm
Carbon Monoxide – CO	630–08–0, UN1016	Flammable[5]	1200 ppm	3760 ppm	50 ppm
Chlorine – Cl_2	7782–50–5, UN1017	Toxic, corrosive, oxidizer	10 ppm	293 ppm	1 ppm[4(C)]
Chlorine Dioxide – ClO_2	10049–04–4, NA9191	Toxic, oxidizer	5 ppm	250 ppm	0.1 ppm
Chlorine Trifluoride – ClF_3	7790–91–2, UN1749	Toxic, oxidizer	20 ppm	299 ppm	0.1 ppm[4(C)]
Diborane – B_2H_6	19278–45–7, UN1911	Highly toxic, flammable	15 ppm	80 ppm	0.1 ppm
Dichlorosilane – SiH_2Cl_2 (HCl)	4109–96–0, UN2189	Toxic, corrosive, flammable	50 ppm	314 ppm	5 ppm[4(C)]
Ethylene Oxide – C_2H_40	75–21–8, UN1040	Flammable[5]	800 ppm	4350 ppm	1 ppm
Fluorine – F_2	7782–41–4, UN1045	Highly toxic, oxidizer	25 ppm	185 ppm	0.1 ppm

Because of their acute toxicity and high level of regulatory oversight, the gases listed here should not use this generic SOP, but rather a gas-specific version – contact the EHS Department.

Reference: University of California, Santa Barbara - Environmental Health & Safety

Gas and Formula	CAS and UN or NA No.	UBC Class[1]	IDLH[2]	LC50[3]	PEL[4]
Germane – GeH_4	7782–65–2, UN2192	Toxic, flammable	6 ppm[7]	622 ppm	0.2 ppm[7]
Hydrogen Bromide – HBr	10035–10–6, UN1048	Corrosive[6]	30 ppm	2860 ppm	3 ppm
Hydrogen Chloride – HCl	7647–01–0, UN1050	Corrosive[6]	50 ppm	2810 ppm	5 ppm[4(C)]
Hydrogen Cyanide – HCN	74–90–8, UN1051	Highly toxic, flammable	50 ppm	40 ppm	10 ppm
Hydrogen Fluoride – HF	7664–39–3, UN1052	Toxic	30 ppm	1300 ppm	3 ppm
Hydrogen Selenide – H_2Se	7783–07–5, UN2202	Highly toxic, flammable	1 ppm	2 ppm	0.05 ppm
Hydrogen Sulfide – H_2S	7783–06–4, UN1053	Toxic, flammable	100 ppm	712 ppm	20 ppm
Methyl Bromide – CH_3Br	74–83–9, UN1062	Toxic, flammable	250 ppm	1007 ppm	20 ppm[4(C)]
Methylisocyanate – CH_3NCO	624–83–9, UN2480	Highly toxic, flammable	3 ppm	22 ppm	0.02 ppm
Methyl Mercaptan – CH_3SH	74–93–1, UN1064	Toxic, flammable	150 ppm	1350 ppm	10 ppm[4(C)]
Nickel Carbonyl – $Ni(CO)_4$	13463–39–3, UN1259	Highly toxic, flammable	2 ppm	18 ppm	0.001 ppm
Nitric Oxide – NO	10102–43–9, UN1660	Highly toxic, oxidizer	100 ppm	115 ppm	25 ppm
Nitrogen Dioxide – NO_2	10102–44–0, UN1067	Highly toxic, oxidizer	20 ppm	115 ppm	5 ppm[4(C)]
Phosgene – $COCl_2$	75–44–5, UN1076	Highly toxic	2 ppm	5 ppm	0.1 ppm
Phosphine – PH_3	7803–51–2, UN2199	Highly toxic, pyrophoric	50 ppm	20 ppm	0.3 ppm

Reference: University of California, Santa Barbara - Environmental Health & Safety

Gas and Formula	CAS and UN or NA No.	UBC Class[1]	IDLH[2]	LC50[3]	PEL[4]
Phosphorus Oxychloride – $POCl_3$	10025–87–3, UN1810	Highly toxic	0.96 ppm[6]	96 ppm	0.1 ppm[7]
Phosphorus Pentafluoride – PF_5	7647–19–0, UN2198	Toxic, oxidizer	2.6 ppm[6]	260 ppm	3 ppm
Phosphorus Trichloride – PCl_3	7719–12–2, UN1809	Toxic, oxidizer	25 ppm	208 ppm	0.5 ppm
Selenium Hexafluoride – SeF_6	7783–79–1, UN2194	Highly toxic	2 ppm	50 ppm	0.05 ppm (as Se)
Silicon Tetrachloride – $SiCl_4$ (HCl)	10026–04–7, UN1818	Toxic, corrosive	50 ppm	750 ppm	5 ppm[4(C)]
Silicon Tetrafluoride – SiF_4 (HF)	7783–61–1, UN1859	Toxic	30 ppm	450 ppm	0.1 ppm
Stibine – SbH_3	7803–52–3, UN2676	Highly toxic, flammable	5 ppm	20 ppm	0.1 ppm
Sulfur Dioxide – SO_2	7446–09–5, UN1079	Corrosive[6]	100 ppm	2520 ppm	5 ppm
Sulfuryl Fluoride – SO_2F_2	2699–79–8, UN2191	Corrosive[6]	200 ppm	3020 ppm	5 ppm
Tellurium Hexafluoride – TeF_6	7783–80–4, UN2195	Highly toxic	1 ppm	25 ppm	0.02 ppm (as Te)
Titanium Tetrachloride – $TiCl_4$	7550–45–0, UN1838	Highly toxic, corrosive	1.3 ppm	119 ppm	—
Tungsten Hexafluoride – WF_6 (HF)	7783–82–6, UN2196	Toxic, corrosive	30 ppm	217 ppm	0.1 ppm

Footnotes:

1. UBC (Uniform Building Code) Class. **Gases listed as either toxic or highly toxic should not use this SOP, but develop a gas-specific SOP**
2. **IDLH (Immediately Dangerous to Life and Health)** values published in 1994 by the National Institute for Occupational Safety and Health (NIOSH).
3. **LC50 data (Lethal concentration 50%):** Lowest reported value, 1 hour adjusted, taken from Dept. of Transportation, Compressed Gas Association, Registry of Toxic Effects of Chemical Substances.
4. **PEL (Permissible Exposure Limit)** values published by Occupational Safety & Health Administration (OSHA). OSHA values used if available; otherwise, Threshold Limit Values (TLV) from ACGIH. (C) = TLV-ceiling limit, an exposure limit not to be exceeded under any circumstances.
5. When used as a refrigerant, Uniform Building Code Class does not apply.
6. IDLH determined by 0.01 of LC50.
7. OSHA PEL

Reference: University of California, Santa Barbara - Environmental Health & Safety