

## Standard Operating Procedure (SOP)

This Standard Operating Procedure (SOP) describes basic chemical safety information for gases under pressure. Prior to conducting work with gases under pressure 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.

### Gases Under Pressure

|   |  |
|---|--|
| 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 gases under pressure (i.e. compressed gases).


### Properties & Hazards

#### General Hazards:

Chemicals in this band present hazards based on the pressurized nature of their storage and use. Gases under pressure are considered generally hazardous and are generally defined as follows:

- Gases which are contained in a receptacle at a pressure of 29 psi. (200 kPa) or more at 20 °C
- Gases which are liquefied or liquefied and refrigerated

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 |
|---|---------------------|----------------------|------------|----------------------|
|  | Generally Hazardous | Gases Under Pressure | H280, H281 | Compressed Gas       |

In addition, UCI organizes compressed gases by hazard class based on toxic, flammable, oxidizing, and corrosive properties. Specific storage and handling guidelines apply to each hazard class. The hazardous properties of gases are detailed as follows:

- If you are working with a toxic gas, refer to the Toxic Gases SOP band. 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:  $\leq 200$  ppm
  - Class II:  $>200$  ppm,  $\leq 2000$  ppm
  - Class III:  $>2000$  ppm,  $\leq 5000$  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 the SDS, this SOP, and Appendix 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. 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 gases under pressure.
- 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 gases under pressure must have completed the “Compressed Gas Safety” training through EHS.
- Before working with compressed gases, all personnel should read and follow the compressed gas program ([https://www.ehs.uci.edu/programs/\\_pdf/safety/compressed-gases-safety-program.pdf](https://www.ehs.uci.edu/programs/_pdf/safety/compressed-gases-safety-program.pdf)) and the TANGO compressed gas handout (<https://ehs.uci.edu/safety/pdfs/compressed-gas-reference-guide.pdf>).
- 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

- Compressed gas cylinders must be double chained and stored in compliance with Cal/OSHA and NFPA code requirements.
- All regulators, valves, and lines must be chemically compatible, the proper size/type, and leak tested before use.
- Reaction vessels or chambers must be located inside of an exhausted enclosure (e.g. fume hood).
- 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 Compressed Gas Program, and Appendices A – C are followed.

### Storage:

- All compressed gas cylinders/containers and storage locations must be clearly labeled.
- Compressed gas cylinders must be upright, double chained, and stored in compliance with Cal/OSHA and NFPA code requirements.
- 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.
- 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 possibly 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 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, flammable, and corrosive gases in a fume hood. Cylinders and reaction vessels must be located inside of an exhausted enclosure.
- Leak test the system prior to use and/or 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.
- 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.

#### **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
  - [Text a pick up](mailto:hwp@uci.edu) to [hwp@uci.edu](mailto:hwp@uci.edu), EHS will pick up your waste within 1-3 days
  - Or visit <https://ehs.uci.edu/enviro/haz-waste/> EHS

### Additional Information

- For additional information about gases under pressure, review the:
- UCI Compressed Gas Program, [https://www.ehs.uci.edu/programs/\\_pdf/safety/compressed-gases-safety-program.pdf](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>

## **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.

Add a generic process/procedure on the safe use of the chemicals within this band.

## APPENDIX B: UCI Hazardous Gas Classification Table

| Gas and Formula   | CAS and UN or NA No. | UBC/CFC Class <sup>1</sup>           | UCI Class <sup>2</sup> | IDLH <sup>3</sup>   | LC50 <sup>4</sup> | PEL <sup>5</sup>        |
|---|----------------------|--------------------------------------|------------------------|---------------------|-------------------|-------------------------|
| Ammonia – NH <sub>3</sub>                               | 7664–41–7, UN1005    | Corrosive <sup>6,7</sup> , flammable | III                    | 300 ppm             | 4000 ppm          | 50 ppm                  |
| Arsine – AsH <sub>3</sub>                               | 7784–42–1, UN2188    | Highly toxic, flammable              | I                      | 3 ppm               | 20 ppm            | 0.05 ppm                |
| Boron Tribromide – BBr <sub>3</sub>                     | 10294–33–4, UN2692   | Toxic                                | II                     | 50 ppm              | 380 ppm           | 1 ppm <sup>5(C)</sup>   |
| Boron Trichloride – BCl <sub>3</sub>                    | 10294–34–5, UN1741   | Corrosive <sup>6</sup>               | III                    | 25 ppm <sup>8</sup> | 2541 ppm          | 5 ppm                   |
| Boron Trifluoride – BF <sub>3</sub>                     | 7637–07–2, UN1008    | Toxic                                | II                     | 25 ppm              | 806 ppm           | 1 ppm <sup>5(C)</sup>   |
| Bromine – Br <sub>2</sub>                               | 7726–95–6, UN1744    | Highly toxic, corrosive, oxidizer    | I                      | 3 ppm               | 113 ppm           | 0.1 ppm                 |
| Carbon Monoxide – CO                                    | 630–08–0, UN1016     | Flammable <sup>6</sup>               | III                    | 1200 ppm            | 3760 ppm          | 50 ppm                  |
| Chlorine – Cl <sub>2</sub>                              | 7782–50–5, UN1017    | Toxic, corrosive, oxidizer           | II                     | 10 ppm              | 293 ppm           | 1 ppm <sup>5(C)</sup>   |
| Chlorine Dioxide – ClO <sub>2</sub>                     | 10049–04–4, NA9191   | Toxic, oxidizer                      | II                     | 5 ppm               | 250 ppm           | 0.1 ppm                 |
| Chlorine Trifluoride – ClF <sub>3</sub>                 | 7790–91–2, UN1749    | Toxic, oxidizer                      | II                     | 20 ppm              | 299 ppm           | 0.1 ppm <sup>5(C)</sup> |
| Diborane – B <sub>2</sub> H <sub>6</sub>                | 19278–45–7, UN1911   | Highly toxic, flammable              | I                      | 15 ppm              | 80 ppm            | 0.1 ppm                 |
| Dichlorosilane – SiH <sub>2</sub> Cl <sub>2</sub> (HCl) | 4109–96–0, UN2189    | Toxic, corrosive, flammable          | II                     | 50 ppm              | 314 ppm           | 5 ppm <sup>5(C)</sup>   |
| Ethylene Oxide – C <sub>2</sub> H <sub>4</sub> O        | 75–21–8, UN1040      | Flammable <sup>6</sup>               | III                    | 800 ppm             | 4350 ppm          | 1 ppm                   |
| Fluorine – F <sub>2</sub>                               | 7782–41–4, UN1045    | Highly toxic, oxidizer               | I                      | 25 ppm              | 185 ppm           | 0.1 ppm                 |
| Germane – GeH <sub>4</sub>                              | 7782–65–2, UN2192    | Toxic, flammable                     | II                     | 6 ppm <sup>8</sup>  | 622 ppm           | 0.2 ppm <sup>9</sup>    |
| Hydrogen Bromide – HBr                                  | 10035–10–6, UN1048   | Corrosive <sup>6</sup>               | III                    | 30 ppm              | 2860 ppm          | 3 ppm                   |
| Hydrogen Chloride – HCl                                 | 7647–01–0, UN1050    | Corrosive <sup>6</sup>               | III                    | 50 ppm              | 2810 ppm          | 5 ppm <sup>5(C)</sup>   |
| 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 <sub>2</sub> 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 <sup>1</sup> | UCI Class <sup>2</sup> | IDLH <sup>3</sup>     | LC50 <sup>4</sup> | PEL <sup>5</sup>       |
|--|----------------------|----------------------------|------------------------|-----------------------|-------------------|------------------------|
| Hydrogen Sulfide – H <sub>2</sub> S                | 7783–06–4, UN1053    | Toxic, flammable           | II                     | 100 ppm               | 712 ppm           | 20 ppm                 |
| Methyl Bromide – CH <sub>3</sub> Br                | 74–83–9, UN1062      | Toxic, flammable           | II                     | 250 ppm               | 1007 ppm          | 20 ppm <sup>5(C)</sup> |
| Methylisocyanate – CH <sub>3</sub> NCO             | 624–83–9, UN2480     | Highly toxic, flammable    | I                      | 3 ppm                 | 22 ppm            | 0.02 ppm               |
| Methyl Mercaptan – CH <sub>3</sub> SH              | 74–93–1, UN1064      | Toxic, flammable           | II                     | 150 ppm               | 1350 ppm          | 10 ppm <sup>5(C)</sup> |
| Nickel Carbonyl – Ni(CO) <sub>4</sub>              | 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 <sub>2</sub>                 | 10102–44–0, UN1067   | Highly toxic, oxidizer     | I                      | 20 ppm                | 115 ppm           | 5 ppm <sup>5(C)</sup>  |
| Phosgene – COCl <sub>2</sub>                       | 75–44–5, UN1076      | Highly toxic               | I                      | 2 ppm                 | 5 ppm             | 0.1 ppm                |
| Phosphine – PH <sub>3</sub>                        | 7803–51–2, UN2199    | Highly toxic, pyrophoric   | I                      | 50 ppm                | 20 ppm            | 0.3 ppm                |
| Phosphorus Oxychloride – POCl <sub>3</sub>         | 10025–87–3, UN1810   | Highly toxic               | I                      | 0.96 ppm <sup>8</sup> | 96 ppm            | 0.1 ppm <sup>9</sup>   |
| Phosphorus Pentafluoride – PF <sub>5</sub>         | 7647–19–0, UN2198    | Toxic, oxidizer            | II                     | 2.6 ppm <sup>8</sup>  | 260 ppm           | 3 ppm                  |
| Phosphorus Trichloride – PCl <sub>3</sub>          | 7719–12–2, UN1809    | Toxic, oxidizer            | II                     | 25 ppm                | 208 ppm           | 0.5 ppm                |
| Selenium Hexafluoride – SeF <sub>6</sub>           | 7783–79–1, UN2194    | Highly toxic               | I                      | 2 ppm                 | 50 ppm            | 0.05 ppm (as Se)       |
| Silicon Tetrachloride – SiCl <sub>4</sub> (HCl)    | 10026–04–7, UN1818   | Toxic, corrosive           | II                     | 50 ppm                | 750 ppm           | 5 ppm <sup>5(C)</sup>  |
| Silicon Tetrafluoride – SiF <sub>4</sub> (HF)      | 7783–61–1, UN1859    | Toxic                      | II                     | 30 ppm                | 450 ppm           | 0.1 ppm                |
| Stibine – SbH <sub>3</sub>                         | 7803–52–3, UN2676    | Highly toxic, flammable    | I                      | 5 ppm                 | 20 ppm            | 0.1 ppm                |
| Sulfur Dioxide – SO <sub>2</sub>                   | 7446–09–5, UN1079    | Corrosive <sup>6</sup>     | III                    | 100 ppm               | 2520 ppm          | 5 ppm                  |
| Sulfuryl Fluoride – SO <sub>2</sub> F <sub>2</sub> | 2699–79–8, UN2191    | Corrosive <sup>6</sup>     | III                    | 200 ppm               | 3020 ppm          | 5 ppm                  |
| Tellurium Hexafluoride – TeF <sub>6</sub>          | 7783–80–4, UN2195    | Highly toxic               | I                      | 1 ppm                 | 25 ppm            | 0.02 ppm (as Te)       |
| Titanium Tetrachloride – TiCl <sub>4</sub>         | 7550–45–0, UN1838    | Highly toxic, corrosive    | I                      | 1.3 ppm               | 119 ppm           | —                      |
| Tungsten Hexafluoride – WF <sub>6</sub> (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                 | <sup>1</sup> 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                 | <sup>1</sup> 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                                      |          |                   | <sup>1</sup> C | X              | X              |
| 10. Detector system                                  |          | X (class I)       | <sup>1</sup> C | <sup>1</sup> C | X              |
| 11. Emergency alarms (and explanatory signs)         |          | X (class I)       | <sup>1</sup> 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                  |          |                   |                |                | <sup>1</sup> C |
| 17. Auto shut-off (manual or detector triggered)     |          |                   |                | X              | X              |
| 18. Exhaust flow alarm                               |          | X (class I)       |                |                | X              |

<sup>1</sup>C = 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 reference guide:
    - 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.

