Compressed Gases
STANDARD OPERATING PROCEDURE

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

1. HAZARD OVERVIEW

This document describes the safety requirements that laboratory workers and supervisors must follow when compressed gas cylinders are used in laboratory. Its purpose is not to have any accident or risk. Prolonged exposure can cause serious damage to health. Hydrogen, carbon monoxide and hydrocarbons are extremely flammable.

2. HAZARDOUS CHEMICALS

A variety of compressed gases are used for UHV camber works, Gas Chromatograph or FT-IR spectrometer. Please refer their SDS always before using them.

1. Argon
2. Air
3. Carbon monoxide (Extremely Flammable, Toxic)
4. Hydrogen (Extremely Flammable)
5. Nitrogen
6. Oxygen
7. Helium
8. Ethane (Extremely Flammable)
9. Ethylene (Extremely Flammable)
10. Propane (Extremely Flammable)
11. Propylene (Extremely Flammable)
12. Butane (Extremely Flammable)
13. 1-Butene (Extremely Flammable)
14. *cis*-2-Butene (Extremely Flammable)
15. *trans*-2-Butene (Extremely Flammable)

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

a. Eye Protection

ANSI compliant safety glasses with side shields should be worn. Chemical splash goggles should be worn when working with larger quantities. If chemical has a skin hazard or is a caustic liquid, a face shield should be worn when splashing onto the face is a possibility.

b. Skin and Body Protection

Wear chemical resistant lab coat, long pants, and closed-toe shoes. These laboratory coats must be appropriately sized for the individual and be

buttoned to their full length. Laboratory coat sleeves must be of a sufficient length to prevent skin exposure while wearing gloves.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

Flame-resistant lab coat will be required, if working with pyrophoric chemicals. **c. Hand Protection**

At a minimum, wear a nitrile chemical-resistant glove. Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

4. ENGINEERING/VENTILATION CONTROLS

All chemicals should be ventilated to an annually certified laboratory chemical fume hood with the sash at the certified position or lower or the ventilation system of the ceiling. The hood flow alarm should be checked to be operating correctly prior to using the hood. Carbon monoxide in a lecture bottle should be used only with a gas manifold, which has been connected to a mechanical pump in a good condition, and a carbon monoxide detector in the room. Its lecture bottle should be secured not to be fall down.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Handling

Always use a proper dolly to carry gas cylinders in building. Avoid inhalation of vapor or mist. Ensure adequate ventilation. Remove all source of ignition; no smoking or electrostatic charge. Beware of vapor accumulating to form explosive concentration. Vapor can accumulate in low areas. Do use right-sized tools and wear heavy protective gloves when connecting a regulator to gas cylinders. Do not breathe any leaked gas. Work in confined spaces. Prevent further leakage or spillage if safe to do so.

Storage

Gas cylinders for UHV works are stored upright and secured in outside hall cabinets if available. Oxygen cylinder has to be separated from hydrogen or combustible materials.
Metal rack is used to restrain the cylinders, and must be bolted to the floor and wall. The cylinders must be restrained by two chains or straps; chains at 1/3 from the bottom

and 1/3 from top of the cylinders. Gas cylinders (H_2, N_2 and Air) for GC systems are stored in room inside to monitor and control the valves immediately. Small gas lecture bottles (hydrocarbons) are usually placed close to the system. Cylinders that are not in use, or empty cylinders should be closed and capped.

Argon: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid strong oxidizing agents.
Air: Keep cylinder closed and away from heat, sparks, and open flame.
Carbon monoxide: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flame, sparks and sodium/sodium oxide, potassium and strong oxidizing agents.
Hydrogen: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents.
Nitrogen: Keep cylinder tightly closed and away from heat, sparks, and open flame.
Oxygen: Keep cylinder tightly closed and away from heat, sparks, and open flame. Avoid phosphorus, organic materials and powdered metals.
Helium: Keep cylinder tightly closed in a cool dry and well-ventilated place.
Ethane: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents.
Ethylene: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents.
Propane: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents.
Propylene: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents.
Butane: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents.
1-Butene: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents. ***cis*-2-Butene**: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents. ***trans*-2-Butene**: Keep cylinder tightly closed in a dry and well-ventilated place. Avoid heat, flames, sparks, and oxidizing agents.

Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

6. SPILL AND INCIDENT PROCEDURES

Gas Leak - Dial 911 and EH&S 951-827-5528
In case of Controllable Leaks
1) If the regulator has leak, do not attempt to tighten it while the cylinder is under pressure. It may cause a bigger leaking. Close the main cylinder valve and move

the cylinder into a safe location. The residual gas trapped in the regulator should be pumped out to the building ventilation system.

2) If a cylinder has leak, only an acceptable solution shall be used to test a leak. Close the main cylinder valve and move the cylinder into a safe location. Residual gas in the cylinder should be removed by a mechanical pump. Commercial cylinder should be safely vented prior to be returned to the supplier.

In case of Uncontrollable Leaks

Evacuate the room immediately. Call 911 from a campus phone or 951-827-5528 for EH&S from cell phone.

In case of Fire,

1) Alert personnel in the immediate vicinity
2) Confine the fire,

   a) Keep yourself between the emergency and an exit while attempting to confine the emergency to avoid being trapped.

   b) If you have been trained to put out small fires or use an extinguisher, fight the fire if you are confident that you will be able to put it out.
   c) If emergency is inside a hood, close the sash, if possible.
   d) Close lab doors, if possible, to prevent spread of smoke or vapors into adjoining rooms and corridors.
   e) For flammable liquid spills, shut off ignition sources, if possible. Avoid unplugging equipment due to possible electrical arc between receptacle and plug. Turning off breaker will work.
3) Evacuate the emergency area. If in doubt, evacuate the building. To evacuate a building, pull the nearest fire alarm pull station on your way out.
4) Summon aid. For emergencies that require response from the fire department, police department, or paramedics, dial 9-911 from a campus phone.
5) For other emergencies or incidents, call EH&S at 827-5528, or campus police 8275222 after hours.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to “Injuries and Medical Treatment” Flipchart posted in the laboratory.

7. DECONTAMINATION

Ensure the ventilation is working well, and release gases slowly into vacuum pump, which is connected to the building ventilation system. Also monitor carbon monoxide release with carbon monoxide detector.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html
General hazardous waste disposal guidelines:

- Do not attempt to dispose of residual waste or unused quantities in cylinder. Return in the shipping container properly labeled, with caps secured and valve protection cap in place. Gas cylinders obtained from the department stockroom have to be returned to refill prior to taking another filled one. Gas cylinders supplied from campus storehouse has to be returned immediately after use or once empty because of demurrage fee. For other empty cylinders, please contact their supplier to return or to refill.
- Affix an on-online hazardous waste tag using the WASTe Program (https://ehs.ucop.edu/waste/#/home) on all waste containers as soon as the first drop of waste is added to the container.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with compressed gases must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

Gas cylinders for UHV works are stored in outside hall cabinets if available. Gas cylinders for GC systems are stored in room inside to monitor and control the valves immediately.

11. SAFETY DATA SHEETS

Online SDS can be found at https://ehs.ucop.edu/sds/#/.

12. DETAILED PROTOCOL

All lab workers who will be using compressed gases must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of compressed gases and understand the hazards.

Lab workers using compressed gases must demonstrate competence to the Principal Investigator or designee by being able to

1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.);

2) list the foreseeable emergency situations;

3) describe the proper response to the emergency situations, and;

4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedent for reaction conditions that have reasonable similarities to new chemistry that is planned with compressed gases described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale- of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) use compressed gases below 1 bar in any given reaction (higher pressure REQUIRE the approval of PI or designee), and
5) discuss ALL issues or concerns regarding these compressed gases with the PI prior to its use.

If there is an unusual or unexpected occurrence when using compressed gases, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using compressed gases. Unusual or unexpected

occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

Replace empty gas cylinder

1) In case of carbon monoxide, ensure carbon monoxide detector is on
2) Borrow a proper dolly from department stockroom.
3) Close the main cylinder valve.
4) Slowly release pressure from regulator into hood to vent.
5) Close the regulator valves.
6) Disconnect the regulator from an empty cylinder.
7) Screw cylinder cap.
8) Deliver the empty cylinder to the stockroom or store temporally in one of hall cabinets.
9) Bring a new gas cylinder to the rack.
10) Safely secure the cylinder using chain clamp.
11) Unscrew cylinder cap.
12) Ensure the main valve is closed.
13) Unscrew the main valve cap.
14) Connect the regulator to the cylinder.
15) Fully open the regulator valves.
16) Get vacuum in the gas manifold and the regulator.
17) Closed the diaphragm valve.
18) Quickly open and close the main cylinder valve to see if the diaphragm valve is working well.
19) If the good sealing is obtained, go ahead. Otherwise, pump the gas in the line and replace the regulator.
20) Set a delivery pressure as needed.
21) Carefully release pressure from regulator.
22) Fully open the main cylinder valve if needed.

SOP Reviewed and Approved by:

Print name: _____

Signature: _____

Approval Date: _____

Acknowledgement

Standard Operating Procedure

Title: _____

By my signature I acknowledge the contents, requirements, and responsibilities outlined in this Standard Operating Procedure (SOP):

Name	Identification*	Signature	Date
Supervisor / Principal Investigator:			

***Identification:** Enter your Student ID, Employee ID, UCR NetID, UCR Email*