**Policies and Procedures for Safe Handling and Use of Compressed Gases in University of South Carolina Laboratories**

**Section 1. INTRODUCTION**

**1.1 Purpose**

Compressed gases are commonly used in many research laboratories at the University of South Carolina. The purpose of this document is to provide guidance to faculty, staff, researchers and students on how compressed gases are to be used and handled safely by implementing best practices and following USC safety policies. The policies and procedures contained in this document must be fully implemented and the forms and appendices accomplished. This document must be printed and kept with the Chemical Hygiene Plan and Lab Safety Manual*.* All authorized users of compressed gases must read this document and sign off in Appendix 3*.*

**1.2 Hazards of Compressed Gases**

A compressed gas is a material or mixture of materials that is 1) a gas at 20oC or less at an absolute pressure of 14.7 psi and 2) that has a boiling point of 20oC or less at an absolute pressure of 14.7 psi and that is liquefied, non-liquefied or in solution. Gases that have no other health or physical hazard are not compressed gases until the pressure in the packaging exceeds an absolute pressure of 40.6 psi at 20oC *(definition from NFPA 55 Standard for the Storage, Use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders and Tanks – 2005 Edition)*.

Compressed gases present both health and physical hazards to users and physical hazards to University property. Failure to safely use and handle compressed gases poses risks that include personnel injury or even a fatality as well as serious property damage. The risks involved are due to the weight of the gas cylinder, its stored energy, reactivity and health effects of specific gases. A falling cylinder and/or uncontrolled release of pressure from a ruptured cylinder, even though the gas itself may be inert can cause serious injury to the user and an equally extensive damage to the laboratory. Uncontrolled release of gases at high pressure (from a damaged cylinder valve, for example) can cut through soft tissue and propel cylinders at high speed through building walls and ceiling.Undetected and uncontrolled release of flammable, reactive or explosive gases can cause fire and explosions.

Health risks from compressed gases include asphyxiation, tissue damage, skin or respiratory irritation and toxicity. Inert gases like helium or argon, and non-toxic gases like carbon dioxide and nitrogen can be hazardous when released in a confined space, displacing breathable air that can cause asphyxiation. Corrosive gases such as hydrogen chloride and bromine can cause tissue damage upon direct contact with these gases. Inhalation, even of very small amount of highly toxic gases such as chlorine and arsine can cause serious health effects or even death.

**Section 2. PROCEDURES AND POLICIES**

* 1. **Preparing to Purchase Compressed Gases**
		+ Determine the minimum reasonable amount and concentration of gas needed for your procedure.
		+ Plan on purchasing minimum required equipment and accessories to safely secure, connect and withdraw contents from the cylinder.
		+ CGA-approved regulator for the specific gas and application
		+ Wall bracket, bench bracket or floor stand
		+ Strap or chain (chain is preferable because straps melt readily in a fire!)
		+ Tubing (rated for the pressure needed in your procedure)
		+ Leak detecting device orsolution (non-corrosive)
		+ Spark-proof, fitted wrench if using flammable gases
		+ Replacement washers for use during cylinder change-out (if required in CGA regulator)
		+ If gas cylinder is to be moved between laboratories within the building or between storage area and laboratory, purchase or obtain access to a cylinder transport cart.
		+ If gas is toxic, corrosive, flammable, reactive or pyrophoric, purchase a gas-specific detector. *Some uses of flammable gas may not require gas detectors. Consult with EH&S to verify requirement.*
		+ Consult EH&S for assistance in conducting a hazard and risk assessment. EH&S will verify that all safety requirements are met and Standard Operating Procedures are written.
		+ Purchase the minimum reasonable amount and concentration of gas needed for the procedure.
		+ Instruct vendor to deliver the gas directly to the laboratory if pre-approved by EH&S or otherwise, to a designated gas storage area.
	2. **Preparing to Use Compressed Gases**
		+ Know the gas you will be using by reading its safety data sheet (SDS). Take note of the hazards, personal protection, precautions and emergency response to an exposure and release.
		+ For gases that are toxic, corrosive, flammable, reactive or pyrophoric, write specific Standard Operating Procedures (SOPs) for using and handling the gas.
		+ Before handling a gas cylinder, wear leather gloves, safety goggles, lab coat and full coverage shoes. Use flame retardant clothing if handling flammable or pyrophoric gases.
		+ Securely restrain cylinder to a wall bracket, bench bracket or floor stand using a strap or chain.Label gas cylinders and gas cabinets, as applicable (see Appendix 2, 6, 7).
		+ Remove cylinder cap only after the gas cylinder has been secured and only when you are ready to connect the regulator. Cylinder cap must be in place at all times that the cylinder is not in use.
		+ Inspect the ALL cylinder parts looking for complete label and markings, intact pressure relief device, dents, corrosion, cracks on the valve, or any contaminant on the thread. If label is missing, if cylinder is dented or if valve is cracked, return the cylinder immediately to the vendor. Brush off or wipe off any dirt, debris or contaminant on the thread or valve using dry lint-free wipes.
		+ Connect the regulator by holding the regulator on one hand to align the connection and hand-tightening the nut several turnswith the other hand. Position the regulator so that the gauge is at a 45 degree angle. Use a spark-proof, fitted wrench to tighten the nut completely. A quarter turn is usually sufficient. Do not over tighten, as this will damage the thread. Remember to always use your hand to engage the nut and thread and tighten the nut initially. Never use a wrench for this initial attachment to avoid damaging the thread.

**NOTICE**

*The gas industry in the United States has developed standardized valve outlet and inlet connections, transfer connections and regulator connections for specific types of gases to prevent misapplication of these hazardous materials. Ensure that the pressure regulator is approved for the specific gas that it will be connected to. Threads on the regulator must match threads on the cylinder valve outlet. NEVER force valve connections that do not fit!*

*Gases may NOT be withdrawn from the cylinder without the use of a pressure regulator.*

*NEVER use lubricant or Teflon tape on pressure regulator threads as they cause damage to the threads.*

*Never rely on the color of the cylinder to identify gases*

* + - Connect only gas-compatible and pressure-compatibletubing or piping to the regulator.
		- Open the cylinder valve by turning the hand wheel slowly in quarter turns until valve is completely open. If gas pressure increase does not register on the regulator gauge after a half turn, close the valve and contact vendor to have the cylinder replaced.
		- Set the regulator outletpressure as required by your procedure.
		- Check that tubing or pipes and fittings are not leaking. Check potential leak at all points of connection using an appropriate leak detection device ornon-corrosive leak detecting solution like Snoop. If leak is detected, close the cylindervalve and the regulator outlet before attempting to repair the leak.

**NOTICE**

*If cylinder valve does not have a hand wheel, use ONLY the special wrench provided or recommended by the gas supplier. Keep this wrench on the valve while cylinder is in use.*

*When using a compressed gas, care must be taken to prevent backflow of atmospheric air or other contaminants into the cylinder. DO not set regulator pressure of compressed gases (acetylene is an exception) below 20 psig or below the operating pressure of your system.*

*Acetylene, on the other hand must NEVER be used at pressures above 15 psi.*

* 1. **Using Compressed Gases**
		+ Follow written SOPs for the specific gas in use.
		+ Always identify contents by reading cylinder label before using, transferring or withdrawing contents from compressed gas cylinders or cryogenic liquid containers. Never use unlabeled gas cylinders; unlabeled cylinders must be segregated and returned to the vendor immediately.
		+ For non-cryogenic liquefied gases with low vapor pressure at ambient temperature, install check valves or traps to prevent backflow contamination from other materials in a process system.
		+ Never place any object on top of a gas cylinder.

**POLICY**

***Highly hazardous gases (toxic, corrosive, flammable, reactive, pyrophoric) may not be used without prior consultation with EH&S.***

***Highly hazardous gases may not be used without written Standard Operating Procedures.***

***Highly hazardous gases may not be used outside of a fume hood, ventilated gas cabinet or a closed system (See Appendix 1).***

***Use and storage of highly hazardous gases in the laboratory requires a gas detection system with audio and visual alarms (See Appendix 1).***

* 1. **Changing Out Cylinders**
		+ Close the in-use cylinder valve by turning the hand wheel to the closed position. If you are unable to turn the valve, do not apply a tool or excessive force. Contact the vendor for assistance.
		+ Shut-off any outlet downstream of the regulator.Carefully release pressurized gas from regulator and gas lines into a fume hood or gas cabinet exhaust duct.
		+ Seal or purge gas lines depending on the type of gas you are using. Disconnect regulator from the valve CGA connection point using a fitted wrench (a non-sparking wrench is required for flammable gases). Connections for gases that are toxic, corrosive, flammable, or pyrophoric may have left-handed threads; these connections are marked with a groove inscribed around the nut. Left-hand threads loosen by turning clockwise.
		+ Reconnect the regulator to the new cylinder using the procedures in section 2.2.

**NOTICE**

*Before disconnecting the regulator, ensure that the cylinder valve is closed and the regulator is relieved of pressure. Vent residual gas through a vent line inserted into a fume hood or gas cabinet duct.*

*Coordinate with Building Maintenance or EH&S personnel to be on standby during the change-out in case the gas cabinet sensor signals an alarm.*

*Gas lines for corrosive gases must be purged and filled with an inert gas during cylinder change out to ensure that no air enters the gas lines and cause corrosion.*

* 1. **Placement of In-Use Cylinders**
		+ Guidelinesdescribed under Section 2.6 – Storage of Compressed Gases below are to be followed for placement of in-use cylinders. Exceptions to some guidelines may be justified in some rare occasions. A hazard and risk assessment by EH&S personnel is required prior to deviating from any guideline listed in section 2.6.

* 1. **Storage of Compressed Gases**
		+ Storage areas must be well ventilated, fire-resistant and dry.
		+ Store cylinders away from heat, flame or temperature extremes. Container temperature should not be allowed to exceed 125oF.
		+ Store cylinders away from combustible and flammable materials.
		+ Do not store cylinders where it can be damaged by an electrical arc or can become part of an electrical circuit.
		+ Store cylinders away from high magnetic-field equipment.
		+ If cylinder is not in-use, keep valve closed and protection cap in secured position whether the cylinder has contents or is empty.
		+ Secure cylinders at all times, regardless of whether they are with contents or empty. Use non-combustible strap or chain to secure a maximum 3 cylinders per chain.
		+ Store cylinders according to hazard class, with sufficient distance or separation between incompatible gases. One-hour fire rated partition or 20 ft. separation is required between flammable and oxidizing gases.
		+ Store pyrophoric gases only in special gas cabinets or storage areas specifically designed for this type of gas.
		+ Store cylinders away from exposure to salt or corrosive fumes to avoid corrosion of cylinder and the valve protection cap threads making the cap difficult to install or remove.
		+ Store cylinders away from locations where they can be struck or objects can fall on them such as doorways, walkways and other major thoroughfares.
		+ Designate an area for empty cylinders separate from cylinders with contents.
		+ Storage areas must be protected from ALL unauthorized users.
		1. How many cylinders can I store in my laboratory room?
* Use and store a reasonable number of gas cylinders so that all storage guidelines in Section 2.6 can be successfully met.
* In general, one cylinder of a unique gas that is in-use (connected to a system/process) and one back-up cylinder for that unique gas can be stored in a lab room.
* Any other cylinder that will be used within the next 2 months or so may or may not be stored depending on the amount of in-use and back-up cylinders already in the lab.
* Store only in-use cylinders of toxic, corrosive, and pyrophoric gases especially if they are used only occasionally, in small amounts or for short periods of time. Store back-up cylinders in designated cylinder storage area.
* Keep a maximum of 3 cylinders of flammable gases as much as possible to allow nearby labs to store and use flammable gases without exceeding allowable quantities within the fire control area.
* Store back-up cylinders for multiple, manifolded, in-use cylinders in a designated cylinder storage area outside of the laboratory.
	1. **Transporting Compressed Gases**
		+ Do not drag, roll or slide cylinders.
		+ Never try to catch a cylinder from falling.
		+ Never lift a cylinder by its valve protection cap.
		+ Never transport a gas cylinder in horizontal position.
		+ Never transport a cylinder with pressure regulator attached.
		+ Ensure that valve protection cap is secured on a cylinder for transport.
		+ Always use a cylinder cart equipped with a chain to transport ALL gas cylinders.
		+ Small lightweight cylinders, such as lecture size cylinders may be designed without valve protection cap. Do not carry these cylinders by hand; use a rolling cart and secure cylinder on the cart. Dropping these cylinders and damaging the valve can cause the valve stem to expel and cause serious injury.

**NOTICE**

*If valve protection cap is not secured on the cylinder and the cylinder is dropped, the valve can get damaged or sheared off, rapidly releasing pressure and propelling the cylinder like a rocket.*

**POLICY**

***Gas cylinders may not be transported by cart across any road with vehicular traffic.***

***Gas cylinders may not be transported using a private vehicle.***

***Only gas vendor and authorized USC personnel with hazardous material transport permit may transport cylinders using an official USC vehicle*.**

* 1. **Disposal of waste cylinders**
		+ All unwanted, returnable gas cylinders, empty or with contents must be returned to the gas vendor. Ensure that cylinders for pick-up by the vendor have the valves closed and the valve protection cap secured in place.
		+ Unknown and/or unused, non-returnable gas cylinders, with contents or empty, of any size (including lecture bottles) are to be discarded as hazardous waste through Environmental Health and Safety. Please contact the Hazardous Waste Manager at (803) 777-5269 or 777-1935.

**Section 3. EMERGENCY SHUTDOWN AND CONTACT PERSONS**

**POLICY**

***All laboratories using highly hazardous gases (toxic, corrosive, flammable, reactive, pyrophoric) must have written emergency shut-down checklist for procedures involving gases (Appendix 5). Emergency shutdown is to be implemented ONLY WHEN PERSONAL SAFETY IS NOT COMPROMISED.***

***Emergency numbers for personnel who can assist and/or provide information needed during an incident involving highly hazardous gases must be provided.***

**Section 4. REFERENCES**

Regulatory Codes and Standards – OSHA, ACGIH and NIOSH Exposure Limits, International Fire Code

Safety Data Sheets for compressed gases

Handbook of Compressed Gases, 5th Edition

**Section 5. APPENDICES**

Appendix 1. List of commonly used gases, their hazards, exposure limits, precautions and required controls

Appendix 2. Specific policies for particularly hazardous gas use and handling in Horizon I

Appendix 3. Compressed Gas Safety training documentation

Appendix 4. Standard Operating Procedures for gases in use in Horizon 1 Room \_\_\_\_

Appendix 5. Emergency contacts and shutdown checklist for particularly hazardous gas incidents

Appendix 6. Safe Use and Handling of Compressed Gases – Checklist and Gas cylinder label

Appendix 7. Template for gas cabinet label

**APPENDIX 1. Hazards, exposure limits, required controls and precautions for commonly used gases. Consult with EH&S if the gas you are planning to use is not listed on this table.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Gas | Exposure Limits 1\*\* | Exposure Limits 2\*\* | Lower Explosive Limit*(% by volume)* | Hazards | Required Controls\* | Special precautions and best practices |
| Carbon dioxide, nitrogen, helium, argon |  |  |  | Simple asphyxiant | Oxygen monitor if used small room with unreliable ventilation |  |
| Nitrous oxide |  |  |  | Oxidizer | Oxygen monitor if used small room with unreliable ventilation | Store away from flammables |
| Oxygen |  |  |  | Oxidizer |  | Away from flammablesNo grease or oil on piping, fittings and cylinder tools |
| Acetylene\*\*\* | 2500 ppm *(NIOSH, Ceil)* |   | 2.5 | Flammable | Gas cabinet, Gas detection, SOP | Use non-sparking tools for cylinder change-out |
| Ethylene | 200 ppm *(ACGIH TLV, TWA)* |   | 2.7 | Flammable | Gas cabinet, Gas detection, SOP | Use non-sparking tools for cylinder change-out |
| Hydrogen\*\*\* |   |   | 4.0 | Flammable | Gas cabinet, Gas detection, SOP | Use non-sparking tools for cylinder change-out |
| Methane\*\*\*  | 1000 ppm*(ACGIH, TWA)* |   | 5.0 | Flammable | Gas cabinet, Gas detection, SOP | Use non-sparking tools for cylinder change-out |
| Arsine | 0.005 ppm *(ACGIH TLV, TWA)* | 0.05 ppm *(OSHA PEL, TWA)* |  | Highly Toxic | Gas cabinet, Gas detection, SOP | Minimum amount based on procedure |
| Bromine | * 1. ppm

*(ACGIH TLV, TWA)* | * 1. ppm or 0.7 mg/m3

*(OSHA PEL, TWA)* |  | Highly ToxicCorrosive | Gas cabinet, Gas detection, SOP | Complete purging of gas lines before and after use |
| Chlorine | 0.5 ppm *(ACGIH TLV, TWA)* | 0.5 ppm *(OSHA PEL, TWA)* |  | Toxic | Gas cabinet, Gas detection, SOP |  |
| Hydrogen Sulfide | 10 ppm*(ACGIH TLV, TWA)* | 10 ppm*(OSHA PEL, TWA)* |  | Toxic | Gas cabinet, Gas detection, SOP |  |
| Ammonia\*\*\*\* | 25 ppm *(ACGIH TLV, TWA)* | 50 ppm *(OSHA PEL, TWA)* |  | Toxic, Corrosive | Gas cabinet, Gas detection, SOP | Complete purging of gas lines before and after use |
| Sulfur dioxide | 0.25 ppm *(ACGIH TLV, STEL 15 min)* | 5 ppm*(OSHA PEL, TWA)* |  | Toxic, Corrosive | Gas cabinet, Gas detection, SOP | Complete purging of gas lines before and after use |
| Hydrogen chloride | 1. ppm

*(ACGIH, Ceil)* | 5 ppm *(OSHA PEL, Ceil)* |  | Toxic, Corrosive | Gas cabinet, Gas detection, SOP | Complete purging of gas lines before and after use |
| Carbon monoxide | 25 ppm*(ACGIH TLV, TWA)* | 50 ppm *(OSHA PEL, TWA)* | 12.5 | Toxic, Flammable | Gas cabinet, Gas detection, SOP |  |

*\**Required control applies only when gas concentration is at or above PEL and/or LEL for the gas.

*\*\*Ceil*- ceiling limit; *TLV* – threshold limit value; *TWA* – time weighted average; *PEL* – permissible exposure limit

\*\*\*Gas cabinet requirement may be waived based on circumstances of use. Consult with EH&S.

\*\*\*\*Gas detection may be waived based on total volume in-use and stored.

*NIOSH* – National Institute for Occupational Safety and Health; *ACGIH* – American Conference of Industrial Hygienists; *OSHA* – Occupational Safety and Health Administration

**APPENDIX 2. Specific Policies for Particularly Hazardous Gas Use and Handling in Horizon I**

The Horizon I building is equipped with a sophisticated gas detection system that monitors concentration of target gases and signals an alarm once established set points are reached for the gases being monitored to alert occupants of a developing hazardous condition.

There are various categories of hazardous gases being monitored in Horizon I: flammable, toxic/highly toxic and corrosive gases. The gas detection system is designed to signal an alarm before the lower explosive limit of flammable gases is reached. Similarly, an alarm is signaled to alert workers before a harmful concentration of the toxic, highly toxic and corrosive gases is reached.

Although a gas sensor is designed to detect and can be calibrated for a specific target gas, most gas sensors are cross-sensitive – they tend to “see” other gases as well as many other chemical vapors. The release of chemical vapors and other non-target gases combined with the cross-sensitivity of gas detectors results in false alarms that can substantially disrupt research and other operations in the building. Therefore, it is very important that researchers implement work practices that will limit the release of potential false alarm triggers to ensure that the alarm signaled is limited to accidental or uncontrolled releases of hazardous gases specifically being monitored.

Horizon I researchers must observe the following policies in addition to the policies described elsewhere in this document:

1. Planned use of particularly hazardous gases (toxic, corrosive, flammable, reactive, pyrophoric) must be reported to EH&S prior to purchasing. Send the following information to jlocke@mailbox.sc.edu: name of gas or gas mixture, concentration of each component of the mixture, size of cylinder, volume of gas in cylinder, brief description of procedure where gas is to be used. Smaller cylinder may be required to adhere to the maximum allowable quantity set by the International Fire Code.
2. All gas cylinders, upon receipt, must be labeled with a hangtag provided by EH&S (Appendix 6). Write the following information on the space provided: Cylinder ID#, Received date, In-use location, Principal Investigator and Lab contact number. Cylinder ID number should start with the PI’s initials, followed by a unique number created for the cylinder that corresponds with an entry in your chemical inventory. For example, a gas cylinder of carbon monoxide owned by Lee Wooley may have a cylinder ID# LW-0056. This cylinder ID would be listed in Lee Wooley’s inventory with complete details including the CAS#, concentration, cylinder size, volume.
3. Cut the bottom panel of the hangtag along dotted lines to indicate correct status of the cylinder (FULL, IN USE or EMPTY). See Appendix 6.
4. All NEW highly hazardous gases are to be delivered and stored initially in the gas cylinder bay by the loading dock in Horizon I unless the gas cylinder is a replacement for a gas that has been approved and used previously in that particular laboratory that ordered it.
5. Every cylinder brought inside or taken out of the cylinder bay is to be logged into the cylinder inventory logbook located inside the cylinder bay area. Before check-in, label the cylinder with a hangtag (See Appendix 6). During check-in, record the following information on the logbook: Date received, Cylinder ID, Principal Investigator, In-use location, Person that received the cylinder and signature. During checkout, locate the cylinder on the logbook, using cylinder ID, then record the checkout date.
6. Only authorized personnel (always accompanied by an assistant) who were issued keys to the cylinder bay may bring in or take out gas cylinders. If you don’t have a key, contact Kevin Kent for access to the cylinder storage bay.
7. **Highly hazardous gases may be transported to the lab only upon approval by EH&S. Approval is granted when laboratory has established all required SOPs and controls (gas cabinet or fume hood and gas detection). An e-mail approval will be sent to Building maintenance (Kevin Kent) who will provide access to the cylinder bay storage. Gases may be delivered directly to the laboratory ONLY if the gas cylinder is a replacement to an existing approved gas or if the new gas is pre-approved by EH&S.**
8. Cylinders are to be transported ONLY within a building and ONLY IF using an approved cylinder transport cart equipped with a chain to secure the cylinder during transport.
9. All chemicals, especially volatile substances, are to be treated as potential gas alarm triggers.
* Limit the use of volatile substances to fume hoods and other ventilated enclosures. Do not purchase solvents in 5-gallon or larger containers. It is very difficult to move these into the fume hood and spillage is very likely when dispensing contents into smaller containers.
* Transport chemicals in closed leak-proof containers inside a secondary plastic container to contain potential spills.
* If volatile chemical is spilled, contain and cover with absorbent immediately. If spilled chemical is an inhalation hazard, leave the laboratory and post DO NOT ENTER on the door. Call USCPD at 777-4215 and EH&S at 777-5269. If chemical is not an inhalation hazard, clean up the spill using your lab chemical spill kit.
* If any spill or procedure that DOES NOT involve monitored gas triggers an alarm, report immediately to Group Safety Officer. See #12 for further course of action.
* If any procedure that involves a monitored gas triggers an alarm, report incident immediately to Group Safety Officer. See #12 for further course of action.
1. Handle and use gases as described in *Policies and* *Procedures for Handling Compressed Gases in USC Laboratories.*
	* Label all gas cabinets with the identity of gases stored inside. Template label can be found in Appendix 7 of this document.
	* Establish and implement written Standard Operating Procedures for use of all highly hazardous gases.
	* Incorporate gas cylinder change-out in written Standard Operating Procedures.
2. Establish and implement (**only when personal safety is not compromised**) written lab and/or process Emergency Shutdown checklist in the event of an emergency that requires building evacuation.
3. Implement emergency response procedure specific to the alarm signal heard in the building.
* **Local alarm on a floor (Ground, 1st, 2nd, 3rd or 4th)** – A flashing amber/yellow alarm on the gas detection panel in the service corridor can mean either one of the following: battery power is low, sensor is failing, or system is on bypass. If the flashing yellow light is combined with a steady red light, it means a gas sensor detected a gas concentration at or above the level 1 set point but below the level 2 set point. The detection panel view screen indicates the exact cause of the alarm. If level 1 alarm was triggered by a gas release, the strobe light inside the lab where gas release was detected will also be flashing.

Level 1 alarm is set at concentrations below the permissible exposure limit, which allows for researchers to investigate and correct the problem that caused the alarm, without compromising safety. If the cause of the level 1 alarm is a gas leak in a specific laboratory room, the following course of action must be implemented by the lab personnel who witnessed the alarm. Lab personnel witness looks at the gas detection view screen in the service corridor to determine exact cause of alarm. Battery and sensor fail alarm must be reported to (803) 587 4243 and EH&S (803) 777-5269. If alarm is due to gas detected by a sensor, determine the specific gas and location of sensor.

1. Lab personnel witness report incident immediately to Group Safety Officer and Principal Investigator, then to Building Maintenance (803) 587 4243 and EH&S (803) 777-5269. Emergency contact information for specific labs are posted on the Hazard Information Notice posted outside the entrance door.
2. Lab personnel in charge of the lab or lab member performing the experiment where gas is detected turns off gas cylinder source (except for centrally supplied hydrogen) and shuts down all other components of the experimental system immediately. Lab personnel identify the source of leak, repair the leak and verify that leak has been repaired. Turning off the gas source is very important in order to avoid gas concentration from reaching the level 2 set point. Use inert gas such as helium or argon to investigate, repair and recheck leaky tubings and/or connections.
3. Authorized EH&S personnel verifiesthat leak has been repaired and clears the incident.
4. Building Maintenance or EH&S personnel reset*s* the gas detection panel.
	* **Building evacuation alarm** – Characterized by red light flashing in the gas detection panel, strobe lights flashing in all hallways and rooms in the building and a voice announcement instructing ALL occupants to leave the building because a gas release has been detected. This alarm is triggered when 1) gas sensor detects a health hazard gas concentration at or above the Level 2 set point, 2) gas sensor detects at least 25% LEL hydrogen in the riser, plenum or corridor and/or 3) gas sensor detects at least 37.5 % LEL hydrogen and other flammable gases in the laboratory or gas cabinet. The gas detection system will instruct occupants to evacuate the building.
5. All building occupants leave the building using the nearest stairway.
6. If the alarm originated from your laboratory room, call 911 on your way out of the building to provide information about the incidentto Emergency dispatch.. Be prepared to provide the following information:
7. Your name and call back phone number
8. What gas was detected/released
9. Location – building and room #
10. Any injured person, description of injury and his/her location
11. What procedure was being performed that caused the gas release
12. Any action performed to mitigate the release (i.e. procedure was shutdown, main gas cylinder valve was turned off, etc.)
13. Other relevant information that can help Emergency responders
14. If the alarm originated from your laboratory room, proceed to the Incident Command Center set up by the Columbia Police Department (look for a red, marked SUV with green strobe light flashing) and provide requested information surrounding the incident to the Incident Commander.
15. EH&S and Building Maintenance personnel assist Emergency Responders by providing requested information about the building and laboratory.
16. Emergency responders enter the laboratory to investigate and stabilize or remediate the incident area.
17. Emergency Responders issue clearance to reoccupy the building.
18. Building Maintenance or EH&S resets gas detection panel and EH&S Fire Safety resets the fire panel.
19. Building occupants reenter the building.

**APPENDIX 3\*. Acknowledgement of the Policies and Procedures for Safe Handling and Use of Compressed Gases in University of South Carolina Laboratories (this document).**

I, (Principal Investigator printed name and signature ) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ certify that the following personnel have read and understood the content of the *Policies and Procedures for Safe Handling and Use of Compressed Gases in University of South Carolina Laboratories*.

|  |  |  |  |
| --- | --- | --- | --- |
| Lab Personnel | Name | Date  | Signature of Lab Personnel |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
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| 15 |  |  |  |

\*Print additional pages as necessary

**APPENDIX 4. Standard Operating Procedures In-Use in Horizon I Room \_\_\_\_\_.**

**APPENDIX 5. Emergency contacts and shutdown checklist for particularly hazardous gas incidents**

1. **Emergency Contacts**

EMERGENCY – 911

USC Police Department NON-Emergency – (803) 777 4215

Principal Investigator –

Group Safety Officer -

Building Maintenance (Kevin Kent) – (803) 587 4243

Environmental Health and Safety – (803) 777 5269, (803) 5288191, (803) 351-9874

 **B. Emergency Shutdown Checklist**

1.

2.

3.

**APPENDIX 6. Safe Use and Handling of Compressed Gases – Checklist and Gas cylinder label**

General

[ ]  Amount on hand is not excessive; equivalent to what is needed for my procedure plus necessary back-up.

[ ]  Cylinders are stored away from egress, walkway, doorway, and sources of heat, electricity and magnetic field.

[ ]  Cylinders are properly segregated (flammables away from oxidizers or toxic gases).

[ ]  Cylinders are upright, secured with a chain, or floor-type securement.

[ ]  Cylinder labels are intact and readable.

[ ]  Cylinders are free of any visual damage and are not rusty or dented.

[ ]  Cylinder hydrostatic test is within 5-10 years depending on cylinder rating.

[ ]  Cylinder valve is not leaking.

[ ]  Cylinders are delivered by supplier directly to the laboratory.

[ ]  Cylinders are transported only within the building and using a cart with chain designed and approved for cylinder transport. Small cylinders are transported secured in a rolling cart.

[ ]  Only CGA-approved regulator is used.

[ ]  Fittings and tubing used are rated for the working pressure required by the procedure.

[ ]  Valves, fittings and tubing are tested for leaks periodically and each time the procedure is performed.

[ ]  Old, unwanted cylinders are disposed of through the gas vendor.

**Flammable Gases**

[ ]  Non-sparking tools are used to attach valves, fittings and tubing and to change out cylinders.

[ ]  Gas detection is in place for heavy and long-term use of the gas.

[ ]  Gas detector is placed near the source and the point of use and located where the leaked gas is released and can accumulate.

[ ]  Gas detector is calibrated every 12 months or as recommended by the manufacturer of the unit.

[ ]  Written SOP for the use of flammable gas is established.

[ ]  Detailed cylinder change-out procedure is part of the SOP.

**Corrosive Gases**

[ ]  Gas cylinder is secured and dispensed inside a gas cabinet. Gas cabinet is labeled with its content.

[ ]  Gas detection is in place for any type of use of the gas.

[ ]  Gas detector is placed near the source and point of use and located where the leaked gas is released and can accumulate.

[ ]  Gas detector is calibrated every 12 months or as recommended by the manufacturer of the unit.

[ ]  ONLY Stainless steel and other corrosion-resistant valves, fittings and tubing are used; fittings and tubing are made of the same material.

[ ]  Written SOP for the use of corrosive gas is established.

[ ]  Purging of gas lines with inert gas before and after each procedure is performed as part of the SOP.

[ ]  Leak check with inert gas before each procedure is performed as part of the SOP.

[ ]  Detailed cylinder change-out procedure is part of the SOP.

**Toxic Gases**

[ ]  Gas cylinder is secured and dispensed inside a gas cabinet. Gas cabinet is labeled with its content.

[ ]  Gas detection is in place for any type of use of the gas.

[ ]  Gas detector is placed near the source and point of use and located where the leaked gas is released and can accumulate.

[ ]  Gas detector is calibrated every 12 months or as recommended by the manufacturer of the unit.

[ ]  ONLY Stainless steel and other corrosion-resistant valves, fittings and tubing are used; fittings and tubing are be made of the same material if possible.

[ ]  Written SOP for the use of toxic gas is established.

[ ]  Purging of gas lines with inert gas after each procedure is performed as part of the SOP.

[ ]  Leak check with inert gas before and after each procedure is performed as part of the SOP.

[ ]  Detailed cylinder change-out procedure is part of the SOP.

Cylinder ID# \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Received Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In-Use Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

PI: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab Contact #: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**EMPTY**

**IN USE**

**FULL**

**STATUS INDICATED ON BOTTOM PANEL**

Cylinder ID# \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Received Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In-Use Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

PI: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab Contact #: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**EMPTY**

**IN USE**

**FULL**

**STATUS INDICATED ON BOTTOM PANEL**

Cylinder ID# \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Received Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In-Use Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

PI: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab Contact #: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**EMPTY**

**IN USE**

**FULL**

**STATUS INDICATED ON BOTTOM PANEL**

Cylinder ID# \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Received Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In-Use Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

PI: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab Contact #: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**EMPTY**

**IN USE**

**FULL**

**STATUS INDICATED ON BOTTOM PANEL**

Cylinder ID# \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Received Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In-Use Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

PI: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab Contact #: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**EMPTY**

**IN USE**

**FULL**

**STATUS INDICATED ON BOTTOM PANEL**

Cylinder ID# \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Received Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In-Use Location: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

PI: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab Contact #: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**EMPTY**

**IN USE**

**FULL**

**STATUS INDICATED ON BOTTOM PANEL**

**Appendix 7. Sample gas cabinet label.**

**Laboratory information**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 1 | 2 | 3 |
| Gas supplied to Rooms:  |  |  |  |
| Principal Investigator and phone #:  |  |  |  |
| Lab Contact and phone #: |  |  |  |

**Gas Cylinder information**

Name of gas: Carbon monoxide in air

Volume in cylinder: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Composition** | **Concentration** | **Vapor density****(Air=1)** | **Hazards** | **Occupational Exposure Guidelines\*** | **Lower Flammability Limit** | **Upper Flammability Limit** | **Alarm Set point 1** | **Alarm Set point 2** |
| Carbon monoxide | 1000 ppm | 0.97 | Flammable,Fatal if inhaled | 25 ppm *(ACGIH TLV, TWA)*50 ppm *(OSHA PEL, TWA)* | 12.5% | 74% | 25 ppm | 150 ppm |
| Air | Balance | 1 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

\*ACGIH TLV, TWA – threshold limit value concentration averaged over an 8-hour period, issued by the American Conference of Industrial Hygienists

\*OSHA PEL, TWA – permissible exposure limit concentration, averaged over an 8-hour period, issued by the Occupational Safety and Health Administration.

**Gas Cylinder Change-out log**

|  |  |  |  |
| --- | --- | --- | --- |
| Date  | Person 1 | Person 2 | Comments |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |