Compressed Gas and Air Cylinder Safety Program

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1. Program Description

UC Riverside users of compressed gases must take precautions to prevent injuries, property damage, and disruption to operations caused by leaks of compressed gas and over-pressurizations. Types of injuries and accidents that will be controlled include:

- Injuries caused by flying objects accelerated by an explosion or pressure release
- Fires and injuries caused by flammable gas ignition
- Injuries caused by inhalation of toxic or asphyxiating gases

This program requires the use of industry standard gas systems, engineering controls, administrative controls, and training. Higher-hazard gas systems may require redundant levels of engineering controls.

2. Scope

To assure that UC Riverside employees and lab users are adequately trained in the inherent hazards of the cylinders and their contents, as well as proper handling, storage, and use according to Cal/OSHA requirements.

Compressed gas cylinders can present a variety of hazards due to their pressure and/or contents. This program covers requirements which must be followed for the use of all compressed gases. In addition to the standard required work practices for inert gases, hazardous gases may require additional controls and work practices including, but not limited to, the use of gas cabinets, gas monitors, emergency shutoffs, proper equipment design, leak testing procedures, and the use of air supplying respirators for certain highly toxic gases.

This program applies to the storage, use, and handling of gases in pressurized portable containers and gas systems. The primary focus of this program is on single gas uses and systems. Additional requirements may be applied to:

- Use of multiple gases in a single control area or building
- Pressure and cryogenic systems
- Large compressed gas facilities, storage areas, or use areas
- Transportation of compressed gases on or across Riverside public roads

3. Hazards

Compressed gas cylinders can present a variety of hazards due to their pressure and/or contents. This program covers recommendations which should be followed for the use of all compressed gases. In addition to the general work practices, specific practices are made for toxic, flammable, cryogenic, and inert gases. Please See Appendix A for a guide to compressed gas hazard assessment and evaluating risk.

Specific hazards will depend on the type of gas but can include some or all of the below:

- **Asphyxiation:** Simple asphyxiation is the primary hazard associated with inert gases. Because inert gases are colorless and odorless, they can escape into the atmosphere undetected and quickly reduce the concentration of oxygen below the level necessary to support life.
- **Fire and Explosion:** Fire and explosion are the primary hazards associated with flammable gases, oxygen, and other oxidizing gases. Flammable gases can be ignited by static electricity or by a heat source, such as a flame or a hot object. Oxygen and other oxidizing gases do not burn, but will support combustion of flammable materials. Increasing the concentration of an oxidizer accelerates the rate of combustion. Materials that are nonflammable under normal conditions may burn in an oxygen-enriched atmosphere.
- **Chemical Burns:** Corrosive gases can chemically attack various materials, including fire-resistant clothing. Some gases are not corrosive in their pure form, but can become extremely destructive if a small amount of moisture is added. Corrosive gases can cause rapid destruction of skin tissue. Cryogenic gases can also cause skin damage ad burns because of the extremely low temperature.
- **Chemical Poisoning:** Chemical poisoning is the primary hazard of toxic gases. Even in very small concentrations, brief exposure to these gases can result in serious poisoning injuries. Symptoms of exposure may be delayed.
- **High Pressure:** All compressed gases are potentially hazardous because of the high pressure stored inside the cylinder (even low-pressure cylinders). A sudden release of pressure can cause injuries by propelling a cylinder or whipping a line.
- **Improper Handling of Cylinders:** Compressed gas cylinders are heavy and awkward to handle. Improper handling of cylinders could result in sprains, strains, falls, bruises, and broken bones. Other hazards such as fire, explosion, chemical burns, poisoning, and cold burns could occur if gases accidentally escape from the cylinder due to mishandling.

4. Definitions

Anesthetic Gas – A gas that may causes loss of sensation with or without the loss of consciousness.

Cal/OSHA – California Occupational Safety and Health Administration.

Ceiling Limit – The maximum exposure limit, which cannot be exceeded for any length of time

CGA – Compressed Gas Association.

Corrosive Gas – A gas that can cause visible destruction of, or irreversible alterations in, living tissue (e.g., skin, eyes, or respiratory system) by chemical action.

Cryogenic Liquids – Gases condensed to liquid form at extremely low temperatures. Example: Liquid Nitrogen is –196°C (– 320°F). The term "cryogenics" applies to all temperatures less than –150°C (–238°F).

DOT – U.S. Department of Transportation.

Flammable Gas – A gas that can be ignited in air.

Compressed Gas – A material that is shipped in a compressed gas cylinder and acts as a gas upon release at normal temperature and pressure or is used or handled as a gas.

Hazardous Gas – A gas that is included in one or more of the following hazard categories: corrosive, flammable, health hazard, oxidizer, pyrophoric, reactive, or toxic.

IDLH – Immediately Dangerous to Life or Health. "An atmospheric concentration of any toxic, corrosive, or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere" (California Code of Regulations, Title 8, Section 5192).

Inert Gas – is one that is non-reactive and very stable. Inert gases are non-toxic and do not burn, explode, or corrode materials, but they are still hazardous because when released they displace oxygen. Displacing oxygen will make the atmosphere in the local area not able to support human or other life.

Leak Test – Testing pressurized apparatus by a reliable method. This may include coating all nonwelded joints with a soap solution which is capable of forming bubbles at leak points, a pneumatic leak down test using accurate gauges, or other effective measures. Gas systems must be leak tested at the following intervals: upon receipt, at installation, periodically during operation & at disconnect/shipping.

LEL (Lower Explosive Limit) – LEL is the lowest concentration of a gas or vapor in the air that can produce ignition or explosion.

Magnehelic – A diaphragm-type pressure differential sensor with a direct reading gauge.

Manometer – An instrument for measuring pressure. A U-tube partially filled with a liquid that indicates the pressure exerted on the instrument by displacement of the liquid.

MAQ (Maximum Allowable Quantity) – The California Fire Code establishes the maximum allowable quantities (MAQ) of flammable or combustible liquids which are permitted in a control area (laboratory or suite of laboratories). The MAQ defines what the total aggregate volume of liquids can be inside of a particular control area.

NFPA – National Fire Protection Association.

Oxidizing Gas – A gas that initiates or promotes combustion in materials, either by catching fire itself or by causing a fire through the release of oxygen or other gases.

Oxygen Deficiency – A condition that occurs when a breathable atmosphere contains less than 19.5% oxygen. Note: normal air contains 20.8% oxygen.

PEL – Permissible Exposure Limit: The maximum concentration of an airborne contaminant to which a worker may be exposed for an 8-hour shift. PELs are established and enforced by Cal/OSHA (California Occupational Safety and Health Administration).

Pyrophoric Gases – Gases that may spontaneously ignite in air at or below 54 º C (130 º F). Specific gases may not ignite in all circumstances or may explosively decompose.

RFO – Restricted Flow Orifice. An in-cylinder device that reduces the maximum gas release rate.

STEL – Short Term Exposure Limit. A maximum time weighted exposure that should not be exceeded for any 15-minute period during a workday.

STP – In Chemistry, Standard Temperature and Pressure or STP is defined as 0 ° C (32 ° F) and 1 atmosphere of pressure (101.325 kPa or 29.92 inches of Mercury).

TLV-TWA –The threshold limit value time weighted average concentration for a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

Toxic Gas – A gas that is poisonous or capable of causing injury or death, especially by chemical means. Health effects may include severe skin or eye irritation, pulmonary edema, neurotoxicity, or other potentially fatal conditions. The criteria used to establish the list for this guideline are:

1. A National Fire Protection Association (NFPA) health rating of 3 or 4;
2. An NFPA health rating of 2 with poor physiological warning properties;
3. Pyrophoric (self-igniting) characteristics or;
4. Extremely low permissible exposure limits in the absence of an NFPA health rating.

5. Responsibilities

Employees/Lab Users:

- Performs all work with compressed gases in accordance with UC Riverside policies and prudent safe work practices.
- Follow all specific lab/work area procedures established by the PIs/supervisors.
- Read the Chemical Hygiene Plan, specific SOPs, and/or relevant SDSs before beginning work with new gases.
- Inspect all equipment daily before use and especially before turning on a gas cylinder.

Principle Investigators/Department Supervisors:

- Ensures that University policies are enforced and safe work practices are followed.
- Includes written safety procedures (SOP) in their laboratory Chemical Hygiene Plan or employee work procedures.
- Ensures all cylinder users have completed required training in the UC Learning Center.
- Assures that proper SDS sheets are in the laboratory or can be accessed in the workplace.
- Provides and maintains gas safety equipment in good working order.
- Conducts and documents laboratory or shop safety self-assessment inspections and at regular intervals.
- Maintain primary responsibility for toxic gas safety in the laboratory.
- Ensures toxic gas program compliance within the laboratory.
- Provides documented training to toxic gas users.
- Determines the minimum amount of a toxic gas needed for the research.
- Ensures that all gases are stored in accordance with campus policy regulations.
- Establishes purchasing specifications (quantity minimization, needed concentrations, etc.)
- Arranges the prompt return of gas cylinders when gas use is completed.
- Provides updates to Environmental Health & Safety (EHS) upon any changes to the laboratory chemical inventory.

Departmental Purchasing Unit, Material Management

- Reviews toxic gas purchase requests and ensures that toxic gas requests are approved by EH&S prior to placing orders
- Informs users of policies regarding toxic gas purchasing

Department Chairs/Directors

- Responsible for establishing and implementing department information and training programs for their respective areas. Delegation of this responsibility can be made to the Principle Investigator (PI), laboratory supervisor, manager and/or safety committee.
- Understand the processes and hazards in the department work areas.
- Ensure that University policies are enforced and safe work practices are followed.
- Provide for and acquire adequate instruction in the use and maintenance of compressed gas cylinders for employees and lab users.

Environmental Health & Safety (EH&S)

- Shall develop and implement this safety policy and revise as necessary.
- Shall provide technical support to departments and employees when questions or concerns arise with regards to safety.
- Ensures that University Compressed Gas Safety programs and safe work practices are used.
- Determines health hazard classifications for previously unlisted gases, including: acute and chronic toxicity, carcinogenicity, flammability, pyrophoricity and corrosivity.
- Provides gas system planning guidance related to new construction and renovation.
- Assists, advises, and provides training as necessary or by request.
- Reviews and approves procedures for all controlled, highly toxic, or hazardous gases.
- Assists, advises, and instructs UCR employees in the care and handling of compressed gas cylinders and gas systems.

6. Program Components

6.1. General Guidelines.

Only properly trained employees should handle and use compressed gas cylinders. Users must know and understand the gases associated with the equipment being used. Note the following protocols to ensure safe handling.

6.1.1. Read the label on the cylinder and identify the contents before using. If the label is illegible or missing, return the cylinder to the supplier.

6.1.2. Consult the Safety Data Sheet for all gases used. Some gases are pyrophoric (phosphine), corrosive (hydrogen chloride), toxic (ethylene oxide), anesthetic (nitrous oxide), or highly reactive (anhydrous ammonia). If you are unsure how to control dangerous properties of a compressed gas, call EH&S at 2-5528.

6.1.3. Know the hazards of the contents and follow appropriate safe use practices for the material inside.

6.1.4. Never work alone when using compressed gas.

6.1.5. Never use a compressed gas in a confined space without proper engineering controls in place. Consult EH&S at x2-5528 for assistance.

6.1.6. Use regulators approved for the specific gas being used.

6.1.7. Do not use a cylinder with unidentified contents. Do not rely on stenciling or the color of the cylinder. All cylinders must be permanently labeled as to their contents.

6.1.8. Cylinders should be marked when empty (example - an empty cylinder may be marked “MT” or a tag placed on the neck of the cylinder.) Empty cylinders must also be separated from full cylinders.

6.1.9. All cylinders are treated as full even when empty. There is always a small amount of gas remaining in the cylinder and this still creates a hazard.

6.1.10. Cylinders must not be refilled except by authorized suppliers.

6.1.11. If a valve cannot be opened by hand, the cylinder should be returned and another obtained. Employees must not attempt to repair cylinders or cylinder valves, or to force stuck or frozen cylinder valves.

6.1.12. If the material in the tank is highly toxic or flammable and you suspect a leak, evacuate everyone out of the area and report it to campus police by dialing 911. After reporting contact your supervisor or lab safety officer.

6.2. Cylinder Handling

Compressed gas cylinders should be handled only by those familiar with the hazards and who can demonstrate safety precautions working with cylinders. Cylinders are heavy and awkward to move and improper handling can result in sprain, strain, falls, bruised, or broken bones. Other hazards such as fire, explosion, chemical burns, poison, and cold burns could occur due to mishandling.

6.2.1. Eye protection and appropriate closed-toe footwear (non-slip soles) should always be used when transporting compressed gas cylinders. Safety toes are recommended as either part of the shoe or overshoes that can be worn over regular shoes. Contact EH&S for help identifying proper footwear at x2-5528.

6.2.2. It is advised to always push cylinder carts and not pull.

6.2.3. Wear the appropriate personal protective equipment when handling cylinders

6.2.4. Cylinders must always be transported on wheeled cylinder carts with retaining straps or chains.

6.2.5. Do not roll or drag a cylinder more than a few feet if necessary to position the cylinder.

6.2.6. Do not remove protective caps until the cylinders are in place. Do not lift the cylinder by the protective cap.

6.2.7. Don’t try to catch a falling cylinder.

6.2.8. Open cylinder valve slowly, directed away from your face. Do not discharge the contents from any gas cylinder directly towards any person

6.2.9. Close the cylinder valve and release all pressure from the downstream equipment at the end of each day.

6.2.10. Remove the regulator and cap the cylinder anytime there an extended non-use period.

6.2.11. Never tighten a protective cap with a tool. The cap should be only be hand tight.

6.2.12. Repair or alteration of a cylinder is prohibited. Damaged or leaking cylinders must be returned to the supplier.

6.2.13. Do not permit cylinders to become part of an electrical circuit

6.2.14. Use non-sparking tools (brass) when working with flammable/explosive materials.

6.2.15. Prevent sparks and flames from contacting cylinders.

6.2.16. Never strike a welding arc on a cylinder.

6.2.17. Do not mix gases in a cylinder.

6.2.18. Never introduce another product into the cylinder.

6.2.19. Use check valves to prevent reverse flow into the cylinder.

6.3. Transporting Cylinders

6.3.1. Compressed gas cylinders shall be stored or transported in a manner to prevent them from creating a hazard by tipping, falling or rolling.

6.3.2. Liquified fuel-gas cylinders shall be stored or transported in a position so that the safety relief device is in direct contact with the vapor space in the cylinder at all times. Open cylinder valves slowly, directed away from your face.

6.3.3. Cylinders without regulators must be chained or strapped at an angle on carts designed for such cylinders.

6.3.4. Compressed gas cylinders must be transported with protective caps in place. Cylinders may be moved on chain equipped hand trucks or carts; they must never be rolled or dragged.

6.4. Cylinder Storage

All compressed gas cylinders must be properly stored in compliance with Cal/OSHA and NFPA code requirements.

6.4.1. All cylinders whether empty or full must be stored upright.

6.4.2. Inside of buildings, cylinders shall be stored in a well-protected, well-ventilated, dry location, at least 20 feet from highly combustible materials such as oil or combustibles.

6.4.3. Assigned storage spaces shall be located where cylinders will not be damaged by passing or falling objects, or subject to tampering by unauthorized persons.

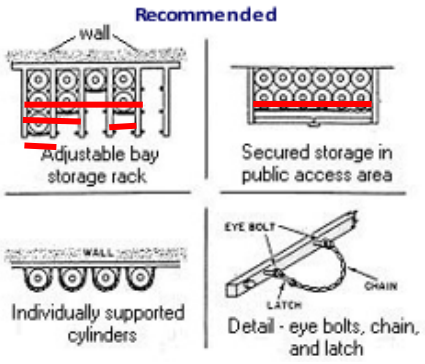
6.4.4. Empty cylinders should be marked or segregated from full cylinders.

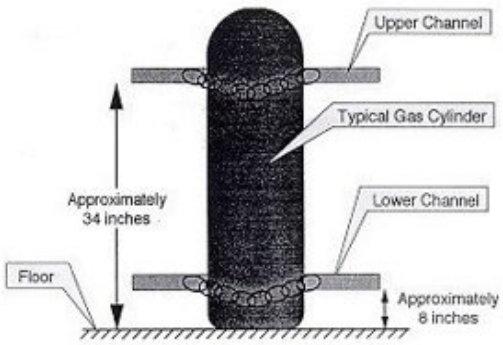
6.4.5. Cylinders should be stored a minimum of 10 feet from lab entrances and exits and away from emergency exits, elevators, stairs, or gangways.

6.4.6. Gas cylinders must be secured to prevent falling due to accidental contact, vibration, or earthquakes. Cylinders must be secured in one of the following ways:

6.4.6.1. A noncombustible, two-point restraint system (e.g., chains) that secures the cylinder at the top and bottom one-third portions.

6.4.6.2. A noncombustible rack, framework, cabinet, approved strapping device, secured cylinder cart, or other assembly that prevents the cylinder from falling.





Each cylinder must be individually secured with two restraints

6.4.7. Cylinders must be segregated by contents. For example, flammable gases must be stored separately from oxidizing gases by a distance of 20 feet or by a non-combustible one-hour fire-rated separation 5-foot high or a minimum of 18" above the tallest cylinder.

6.4.8. Signs required at compressed gas cylinder storage locations will be determined by the UCR Campus Fire Marshal or EH&S. The sign will depend on the types of gas present and could include the ones shown below.

6.4.9. Cylinders with regulators must be upright, attached to the wall or a sturdy structure.

6.4.10. All cylinder storage areas, outside or inside, shall be protected from extreme heat and cold and from access by unauthorized personnel.

6.5. Cylinder Labeling Requirements

6.5.1. Compressed gas cylinders shall be legibly marked for the purpose of identifying the gas content with either the chemical or the trade name of the gas. Such marking shall be by means of stenciling, stamping, or labeling, and shall not be readily removable. Whenever practical, the marking shall be located on the shoulder of the cylinder (OSHA Standard 8 CCR §4649 (d))

6.5.2. A durable label should be provided that cannot be removed from the compressed gas cylinder. Compressed gas cylinders that do not clearly identify its contents by name should not be accepted for use.

6.5.3. Color-coding is not a reliable means of identification; cylinder colors vary from supplier to supplier, and labels on caps have no identification value because many caps are interchangeable.

6.5.4. Tags should be attached to the gas cylinders on which the names of the users and dates of use can be entered. If the labeling on the gas cylinder becomes unclear or defaced so that the contents cannot be identified, the cylinder should be marked “contents unknown” and the manufacturer must be contacted regarding appropriate procedures for removal.

6.6. Piping and Tubing for Conveying Compressed Gas

Hazardous gases must be dispensed using systems that are properly cleaned and compatible with the gas in use. “Burst pressure” of tubing and piping must be twice the maximum pressure on the second stage regulator. Exceptions to this requirement may be made for short sections of tubing when it and the compressed gas cylinder are completely enclosed in a fume hood and low pressures and flow rates are used.

6.6.1. Hard Piping and tubing

6.6.1.1. Use "hard" piping (such as copper and stainless-steel tubing) whenever possible (as opposed to flexible or plastic tubing). Consult a compatibility chart to determine what the most appropriate pipe material is for the gas being conveyed.

6.6.1.2. Do not use cast iron pipe or fittings for anything except compressed air.

6.6.1.3. Never use Teflon tape on cylinder connections or tube-fitting connections. Use Teflon tape only on pipe threads where the seal is made at the threads. All other connections have metal to metal face seals or gasket seals

6.6.1.4. Select tubing compatible with the chemical and pressure properties of the gas being used in the system.

6.6.1.5. Avoid the use of flexible tubing for highly toxic gases.

6.6.1.6. Use appropriately rated flexible lines are suitable for manifold/cylinder connections.

6.6.1.7. Flexible tubing should only be used within "line of sight."

6.6.1.8. Do not run flexible tubing through walls, ceiling spaces, doorways, or other non-visible pathways.

6.6.1.9. Always clamp flexible tubing connections. Use a clamp approved for the maximum allowable pressure that the connection is subject to. Never use wire, which may cut the flexible tubing.

6.6.1.10. Secure and support tubing or piping to keep it in place and to prevent "whipping" if a connection fails under pressure.

6.6.1.11. Do not run flexible tubing across the floor. All tubing should be secured overhead in a cable tray or with hangers attached to structural members.

6.6.1.12. Never attach tubing to electrical conduit, fire sprinkler system piping or components, or water piping.

6.6.1.13. Understand most flexible tubing deteriorates with age or exposure to chemicals or UV light. Replace old flexible tubing before it deteriorates

6.6.1.14. Always leak-check (leak-test) tubing or piping connections when using hazardous gases.

6.6.2. Labeling Guidelines for Piping and Compressed Gas Tubing

A clear and concise approach to labeling compressed gas tubing and piping systems is important for proper hazard communication and ensuring the proper gas/ hazardous material is connected to the intended system/process.

6.6.2.1. The minimum requirement for labeling of compressed gas tubing and piping includes:

- Name of the material/gas within the lines to be placed at the following locations:
    - At the point of connection for the source material to tie into the distribution lines.
    - At each process control valve.
    - At piping flanges.

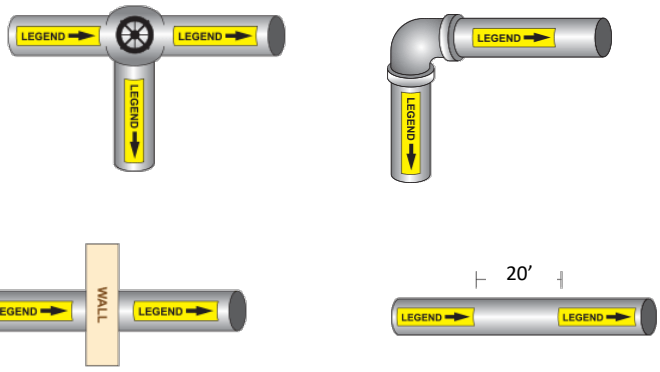
- On both sides of wall, floor, or ceiling penetrations.
- Adjacent to changes in pipe/tubing direction.
- A minimum of every **20 feet**.

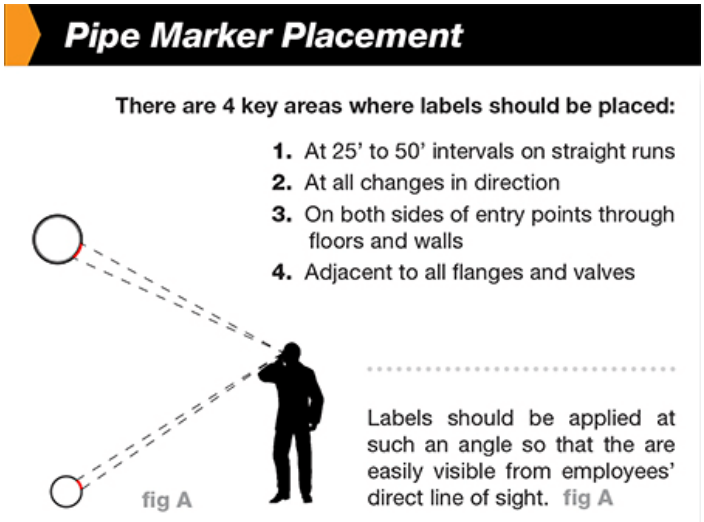
- Name of the process or location to which the lines connect. This would be required if the point of connection for the source material is not co-located with the process or if the complexity of the system drives a more detailed labeling strategy to prevent miss-directed flow of material.

- Labels should be oriented in a manner that could be easily read from a point of normal approach.

6.6.2.2. The following best practices from ANSI are recommended labeling guidelines for compressed gas tubing and piping systems.

- Direction of flow. These labels should be incorporated with the material name or be placed adjacent to the material name.





Note: UCR uses the CFC 53 requirement for labeling **every 20'** rather than the general ANSI requirement of labeling every 25' to 50'.

- Color code the labels based upon the type of hazard posed by the tubing/piping content. The recommended color codes are as followed and are illustrated below:

Yellow	Flammable Fluids & Gasses
Red	Fire-Quenching Fluids
Orange	Toxic or Corrosive Fluids & Gasses
Green	All Water (Potable, Boiler, etc.)
Blue	All Air (Compressed, Lab, etc.)
Brown	Combustible Fluids & Gasses
Purple	Definable by user
Black	Definable by user
White	Definable by user
Gray	Definable by user

- Labels have a minimum length and letter size based upon the tubing or pipe's outer diameter and conform to the following:

Pipe Label Sizing Requirements

Pipe Diameter	Minimum Label Length	Minimum Letter Height
0.75" to 1.25"	8"	0.5"
1.25" to 2.5"	8"	0.75"
2.5" to 8"	12"	1.25"
8" to 10"	24"	2.5"
10"+	32"	3.5"

6.7. Regulators, Valves, and Vacuum Pumps

6.7.1. Regulators

Regulators reduce high pressure gas on a cylinder or process line to a lower usable level. Regulators provide additional safety measures by preventing fire/explosions, chemical or cold burns, poisoning and system over-pressurization.

6.7.1.1. Never use any regulator for gases other than those for which it is intended.

6.7.1.2. Do not force or over tighten a connection.

6.7.1.3. Care must also be taken when using left-handed treaded connectors.

6.7.1.4. Check the bolt for hash marks indicating a left-handed treaded connection.

6.7.1.5. Always stand so the gauges for the regulator are pointing away from you when opening the valve.

6.7.1.6. Open cylinder valve slowly and carefully after the cylinder has been connected to the process.

6.7.2. Valves on Compressed Gas Cylinders

Most compressed gas cylinders require the installation of at least one valve. This valve allows the cylinder to contain gases and allows gas to be filled into or emptied from the cylinder. The cylinder valve is the most vulnerable part of the compressed gas cylinder. Leaks can also occur at the regulator, cylinder stem and at the hose connection.

6.7.2.1. Open valves slowly to control pressure surges and heat of compression.

6.7.2.2. Inspect the valve for damage and foreign materials before connecting to the cylinder.

6.7.2.3. Never use a damaged valve where integrity may have been affected. Discontinue using a valve that operates abnormally, i.e., becomes noisy or progressively harder to operate.

6.7.2.4. Never tamper with regulatory or attempt to tighten or loosen the valve into or out of the cylinder.

6.7.2.5. Never use an automatic operator, adapter, wrenches, or other tools to obtain a mechanical advantage on hand wheel-operated valves without reviewing all safety requirements.

6.7.2.6. Never lubricate cylinder valves or their connections.

6.7.2.7. Never drag, lift, or move a cylinder using the valve or the hand wheel as a handle.

6.7.2.8. Never use a cylinder without a regulator. Always use the correct pressure regulator. Never use the cylinder valve to regulate flow or pressure.

6.7.2.9. Never move cylinders without the transport cap installed.

6.7.3. Restrictive Flow Orifices (RFOs)

Restrictive Flow Orifices are installed in the cylinder valve outlet and provides significant safety benefits for uses of hazardous gases like toxic and highly toxic gases. Consult EH&S for additional information on RFOs.

6.7.4. Vacuum Pumps

6.7.4.1. Hydrocarbon based vacuum pump oil is incompatible with strongly oxidizing and many reactive gases. New vacuum pumps that have inert lubricants and never contained oil-based lubricants must be used with oxidizing and reactive gases.

6.7.4.2. Vacuum pumps must be securely vented to a fume hood or other approved local exhaust system with tubing that is compatible with the gases used.

6.7.4.3. Exhaust lines must be as short as feasible.

6.7.4.4. Vented enclosures may be required for vacuum pumps depending on the toxicity of the gases used.

6.8. Specific Gas and Process Requirements

6.8.1. Cryogenics

6.8.1.1. All cryogenics should be used with caution due to the potential for skin or eye damage due to the low temperature, and the hazards associated with pressure buildups in enclosed piping or containers.

6.8.1.2. A face shield, safety glasses, loose fitting cryogenic handling gloves, lab coat, apron, and cuff less pants are the required equipment for transferring cryogenic fluids.

6.8.1.3. Portable containers should only be used where there is sufficient ventilation. Do not place containers in a closet or other enclosed space where there is no ventilation supply to the area. The buildup of inert gas in such an area could generate an oxygen deficient atmosphere.

6.8.1.4. Special vacuum jacket containers with loose fitting lids should be used to handle small quantities. Vacuum jacketed containers provided by the gas supplier will have overpressure relief devices in place.

6.8.1.5. Any space where cryogenic fluids may accumulate (consider leakage into enclosed equipment) must be vented or protected by overpressure relief devices. Tremendous pressures can result in enclosed spaces as the liquid converts to gas. For example, one cubic centimeter of liquid nitrogen will expand to 700 times this volume as it converts (warms) to its gaseous state.

6.8.1.6. Containers to be filled with cryogenic liquids should be filled slowly to avoid splashing.

6.8.1.7. Cryogenic containers showing evidence of loss of vacuum in their outer jacket (ice buildup on the outside of the container) should not be accepted from the gas supplier. Contact with air (or gases with a higher boiling point) can cause an ice plug in a cryogenic container.

6.8.2. Flammable Gases

6.8.2.1. Gas monitoring systems may be required for specific flammable gases. Contact the EH&S for assistance.

6.8.2.2. Pyrophoric and flammable gases have special handling and storage requirements. Contact EH&S if you plan to use these gases.

6.8.2.3. Flammable gases such as propane, hydrogen, and acetylene always have a red label. However, the color of the cylinder itself is not a good indicator of flammability as different distributors may use different colored cylinders for the same gas. Check the label for flammability.

6.8.2.4. Flammable gases have limits for quantities based on combined totals in a fire control area and also regulations for specific gases. Contact your EH&S representative for assistance.

6.8.2.5. Flammable gases must be stored and used in well-ventilated areas away from flammable liquids, combustible materials, oxidizers, open flames, sparks and other sources of heat or ignition.

6.8.2.6. All lines and equipment associated with flammable gas systems must be grounded and bonded.

6.8.2.7. Spark-proof tools must be used when working with flammable gas cylinders.

6.8.2.8. Portable fire extinguishers must be available for fire emergencies where flammable gas is stored. Contact UCR Fire Prevention if you

need an extinguisher refilled or a new extinguisher added. https://fire.ucr.edu/contact

6.8.2.9. If a flammable gas cylinder develops a leak, attempt to turn off the gas if it is safe to do so. If not, evacuate and restrict area access. Call 911.

6.8.3. Toxic, Corrosive, and Asphyxiant Gases

6.8.3.1. Toxic gases have special handling and storage requirements. Contact EH&S if you plan to use these gases.

6.8.3.2. Hazardous gas (arsine, carbon monoxide, phosgene, phosphine, etc.) cylinders should be stored in a suitable exhausted location.

6.8.3.3. If a toxic gas cylinder develops a leak, evacuate and restrict area access. Call 911.

6.8.3.4. Inert gases, such as nitrogen and carbon dioxide must be treated with caution. If left to leak into closed space, these gases may displace oxygen and create a risk of asphyxiation.

6.8.3.5. Do not store asphyxiant gases in areas without ventilation. This includes environmental chambers (e.g. cold boxes) that do not have a fresh air supply or exhaust system.

6.8.3.6. Any gas that has the potential to displace oxygen in sufficient quantities can cause asphyxiation. Only persons trained, qualified and using a self-contained breathing apparatus (SCBA) with adequate back-up should respond to an inert gas leak or enter an area where an asphyxiant gas could be present. Shut off the source of the gas leak if there is no risk to personnel and ventilate the area. If a person has symptoms of asphyxiation, move the victim to fresh air and obtain proper medical attention.

6.8.4. Corrosive gases

6.8.4.1. Corrosive gases have special handling and storage requirements. Contact EH&S if you plan to use these gases.

6.8.4.2. Keep exposure to corrosive gas as low as possible. Use in fume hood or other vented enclosure only.

6.8.4.3. Avoid contact with skin and eyes.

6.8.4.4. Wear safety goggles when working with corrosive gases.

6.8.4.5. An eye and face wash must be installed within 10 seconds of where corrosive materials, including corrosive gases, are used.

6.8.4.6. Safety plugs in the valves of chlorine cylinders fuse at 157 degrees F. Care must be exercised to see that they are not exposed to steam, hot water, etc. which could produce this temperature.

6.8.4.7. An emergency response procedure must be in place and everyone working in the area must be trained on the procedures.

6.8.4.8. If a corrosive gas cylinder develops a leak, evacuate and restrict area access. Call 911.

6.8.5. Oxygen and Oxidizers

6.8.5.1. Oxidizing gases such as compressed oxygen or nitrous oxide, while not combustible themselves, will cause many materials to burn violently. Never use grease, solvents, or other flammable material on an oxygen valve, regulator, or piping.

6.8.5.2. Do not allow grease or oil to come in contact with oxygen cylinder valves, regulators, gauges or fittings. An explosion or fire can result. Oxygen cylinders and apparatus must be handled with clean hands and tools.

6.8.6. Oxy-Fuel Torch Setups

The use of Oxygen-Fuel torches poses some specific hazards. It is important that only trained and qualified individuals use this type of equipment. Using this equipment requires also requires a UCR hot work permit. Contact EH&S @2-5528 for policy and training for Oxy-fuel systems prior to using this equipment on campus.

6.8.6.1. Oxygen cylinders must have separation from the fuel cylinders when the torch setup is not in use. It is recommended that cylinders be placed on a cart that has a ½-hour firewall separation built in to avoid having to remove the cylinders and store 20 feet apart after each use.

6.8.6.2. Cylinders must be securely fastened to the cart at all times.

6.8.6.3. Unless under constant daily use, the regulators should be removed and the cylinders capped if idle for more than 72 hours.

6.8.6.4. It is important to keep the regulators clean when not attached to the cylinders. They should be stored in a container or bag that is free from dirt, oil, and grease.

6.8.6.5. Prior to installing a regulator on fuel gas, the valve must be checked to make sure it is clean and free of debris. Once verified the employee should stand off to the side of the valve and quickly open and close the valve to purge before connecting the regulator.

6.8.6.6. Acetylene should not be utilized in lines or hoses at a pressure exceeding 15 psi.

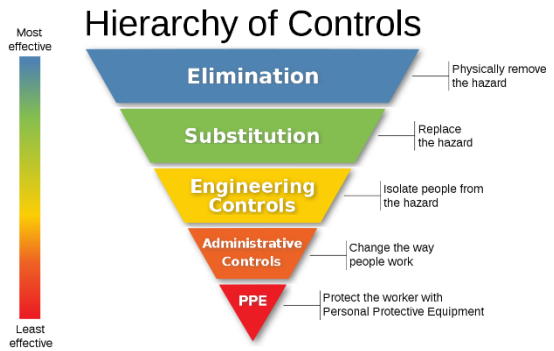
7. Risk Assessment and Control Measures

Compressed gases are hazardous and must be stored and handled carefully. To ensure every hazard associated with gas cylinders used and stored at workplaces and in labs are managed correctly a risk assessment is recommended. A risk assessment examines hazards and estimates the likely consequences if an accident occurs.

Even though a full risk assessment may not be required at some workplaces, compressed gas cylinders present a complex range of hazards. Sometimes one hazard can exacerbate the consequences of another hazard. The cylinder hazards are to consider are:

- Pressure – mechanical energy in a gas bottle is similar to a car travelling 110 mph.
- Chemical – toxic, flammable, asphyxiating, unstable, incompatible, corrosive, etc.
- Physical nature of the cylinder – heavy, awkward to move, slippery, tippy, etc.

The process for risk assessment is done by applying the hierarchy of controls to each hazard.



1. IDENTIFY the hazards – identify each of the gases used, cylinder types, sizes and storage locations. Consult the Safety Data Sheet (SDS) for each gas.
   1.1. Consider the following hazards
   - Chemical properties
   - Job tasks and operating procedures
   - What training is required
   - Layout of workplace or lab and other hazards nearby

- Safety equipment and PPE
- Conveyance requirements (pipe, tubing, etc.)

2. ASSESS the risk – What is the likely outcome if any or all of the above hazards cause an accident? How serious are the consequences (fatal, serious, minor, etc.)? How likely or easy would it be for one of these incidents to occur? Prioritize by severity and likely hood to figure out what hazards are most important to address.
3. CONTROL measures to reduce the risk – Follow these steps.
   3.1. ELIMINATE If possible, eliminate the hazard by changing the process so the gas is no longer needed.
   3.2. SUBSTITUTE – Use a less hazardous gas that can still do the job.
   3.3. ENGINEERING controls – use the gas in a fume hood or employ other equipment to manage the hazard.
   3.4. ADMINISTRATIVE controls – put specific work rules in place to ensure people avoid exposure to the gas.
   3.5. PPE – What PPE can be used to protect workers from the hazards should the above fail to do the job.
   3.6. SUSTAIN – Maintain safe work by conducting regular reviews to ensure the hazards remain controlled.

7.1. Engineering Control Measures

7.1.1. General

The following engineering controls should be implemented when using, transporting, moving, and storing compressed gas cylinders:

- Ensure appropriate ventilation is available in areas where the cylinders are used and stored.
- Install, where required, the following engineering control measures:
  - Continuously exhausted gas cabinets or enclosures.
  - Gas detection systems, alarms, etc.
  - Nitrogen purge system.
  - Automatic shut-off valves.
  - Flashback arrestors.
- Place and tighten the valve protection cap on the compressed gas cylinder when the cylinder is not in use.
- If using flexible (non-fixed) tubing, it is recommended the tubing stay under 10 feet in total length.

Contact EHS @ 951-827-5528 to assist you and/or your department facility manager to determine the proper engineering controls for the laboratory or workspace.

7.1.2. Fixed Pressurized Piping

All compressed gases distributed in fixed pressurized piping and with any of the following properties:

(1) health hazard ratings of 3 or 4;

(2) a health hazard rating of 2 without physiological warning properties, or

(3) a reactivity rating of 3 or 4; or are

(4) pyrophoric or flammable with a flammability class 4 rating

shall have the following engineering controls:

- Excess flow prevention control devices.
- Continuous gas monitoring.
- Automatic shutoff valves.
- Emergency shut-off valves.
- Fume hood purge buttons if they are variable flow hoods.

NOTE: This information is for general guidance. Consult with your EHS representative to determine requirements for your particular usage.

7.2. Administrative Controls

The following administrative controls must be implemented when transporting, moving, and storing compressed gases cylinders.

- Replace or remove damaged or compromised cylinders or equipment.
- Display the appropriate signs (e.g. ePlacard) and labels
- Be familiar with the UCR Chemical Hygiene Plan (CHP) and the Laboratory Safety Manual
- Write and implement SOPs about using, transporting, moving, and storing compressed gas cylinders in the work location.

7.3. Personal Protective Equipment

For personnel and environmental protection against the potential exposure to toxic and highly toxic gases the following personal protective equipment should be used by personnel:

In general:

- When handling cylinders safety glasses or impact resistant goggles must be worn.
- When employee exposure exceeds the Permissible Exposure Limit (PEL) or Threshold Limit Value (TLV) (whichever is lower), respiratory protection will be required.

In Laboratories:

- When handling cryogenic cylinders, a lab coat, apron, long pants without cuffs, safety glasses, face shield, and loose-fitting cryogen rated protective gloves must be worn.
- In labs, laboratory coats or gowns must be worn at all times in the toxic or highly toxic gas area;

NOTE: You must be enrolled in EHS Respiratory Protection program before wearing respiratory protection. Information on enrolling can be found on the EH&S website: https://ehs.ucr.edu/safety/respiratory-protection

8. Reporting requirements

Constant awareness of and respect for equipment, co-workers, and facilities and compliance with all applicable UC Riverside safety rules is mandatory.

Supervisors shall issue warnings and implement disciplinary actions up to and including termination for failure to follow the guidelines of this program.

Employees shall report any safety concerns to their supervisor or EH&S.

10. Training Requirements and Competency Assessment

All persons handling or using cylinders must have basic training at the start of employment or lab use and periodically thereafter. Training will include a review of information on the hazards associated with compressed gas include oxygen displacement, fires, explosions, toxic effects from certain gases and the physical hazards associated with pressurized systems. Special storage, use and handling precautions necessary to control these hazards will also be covered.

The training program will be provided by EH&S and may include in-person or online instruction. Supervisors will provide operational training on specific compressed gas cylinder hazards related to assigned job tasks or lab procedures.

Online training can be accessed 24-hours a day on demand in the UC Learning system. You can access from the direct link below or by searching "compressed gas" in the system using the instructions in the box below.

Compressed Gas online training direct link

Online **eCourses** and **videos** need to be taken in the UCR Learning Center:

https://ucrlearning.ucr.edu

How to Register:

1) Log in with your NetID and Password.
2) Search for the "resource" name listed above OR look under "Required Training" and select the resource name
3) "Register" for the class
4) "Begin" and complete the class for credit

Employees will require refresher training under any of the following conditions:

- Changes in the workplace render previous training obsolete.
- Changes in the types of cylinder systems or equipment used render previous training inadequate.
- Inadequacies in an employee's knowledge of compressed gas cylinders or equipment or observed behavior indicate that the employee has not retained the required training.

11. Information and External References

Title 8 California Code of Regulations

California Fire Code Chapter 53: Compressed Gases

California Fire Code Chapter 55: Cryogenic Fluids

California Fire Code Chapter 58: Flammable and Flammable Cryogenic Gases

California Fire Code Chapter 61: Liquid Petroleum Gases

California Fire Code Chapter 63 Oxidizers, Oxidizing Gases and Oxidizing Cryogenic Fluids

Compressed Gas Association

OSHA Compressed Gas Information Page

NIOSH Compressed Gases Self-Inspection Checklist

Materials Compatibility Chart

Pipe Marking guide

ANSI Standards are available for purchase from ANSI or a copy may be requested from EH&S if applicable to your situation.

- ANSI/CGA V-9 2019 Compressed Gas Cylinder Valves
- ANSI/CGA E-11 Stationary Compressed Gas Cylinder Discharging Manifolds for Working Pressures Up To 3000 PSIG
- CGA E-16-2015 Standard for Compressed Gas Check Valves for Pressures Up to 3500 PSI - 2nd Edition
- ANSI/CGA SB-10 Precautions for Connecting Compressed Gas Containers to Systems
- ANSI/CSA HGV 4.10-2012 (R2019) Standard for Fittings for Compressed Hydrogen Gas and Hydrogen Rich Gas Mixtures
- ANSI/ASME A13.1 Scheme for the Identification of Piping Systems