UCI Environmental Health & Safety

Compressed Gases Safety Program

Responsible Administrator: EHS Safety Specialist
Revised: February 2024

Summary: This section outlines the policy and procedures related to the Compressed Gases Safety Program that is administered through the Environmental Health and Safety (EHS) Department.

1. Program Description 1
2. Scope 1
3. Definitions 2
4. Responsibilities 3
5. Program Components 3
6. Reporting Requirements 5
7. References & Appendices 5

Appendix A: Compressed Gas Cylinder Valves and Regulators
Appendix B: Compressed Gas Safety Reference Guide

1. Program Description

While using compressed gas cylinders, precautions should be taken to prevent injuries, property damage, and disruption to operations caused by leaks of compressed gas and over-pressurizations. Types of injuries and incidents that may 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

This program covers the use and handling of compressed gases, including 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 should 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 Irvine public roads
- Highly hazardous gases such as toxic and highly toxic gases

3. 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

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. One such example is Liquid Nitrogen. It condenses at –196°Celsius (– 320°Fahrenheit). The term "cryogenics" applies to all temperatures less than –150°C (–238°F).

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.

Inert gas – A gas with extremely low reactivity with other substances.

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.

PPE – Personal Protective Equipment

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

Toxic gas – A gas that is poisonous or capable of causing injury or death, especially by chemical means.

4. Responsibilities

4.1 Principal Investigator or Supervisor/Managers

- Ensures that University policies are enforced and safe work practices are followed.
- Provides for and supplies adequate training and instruction in the use and maintenance of gas cylinders by all employees under their control
- Provide specific protocol and procedural training for staff and students in the application of compressed gas safety
- Documents the site-specific trainings provided to employees and students.
- Wears appropriate PPE and enforces PPE use when using compressed gas cylinders
- Consult with the manufacturer and/or EHS on compressed gas set up
- Uses the on-line form to report an injury or an illness: https://www.ehs.uci.edu/forms/report-injury/index.php

4.2 UC Irvine Employees

- Performs all work with compressed gases in accordance with UC Irvine policies and prudent safe work practices.
- Takes Compressed Gas Safety Training, as required
- Receives site-specific trainings from PIs, supervisors and managers
- Follows safety protocol in proper storage, transport and handling of compressed gases
- Wears appropriate PPE
- Reports any unsafe conditions and practices to their supervisor.
- Uses the on-line form to report an injury or an illness to EHS: https://www.ehs.uci.edu/forms/report-injury/index.php

4.3 Environmental Health and Safety (EHS)

- Ensures that University policies are enforced and safe work practices are used.
- Provides required training available through UC Learning Center.
- Reviews and approves procedures for all controlled, highly toxic or hazardous gases.
- Assists, advises, and instructs University employees in the care and handling of compressed gas cylinders and gas systems.

5. Program Components

5.1 Pre-Use

- Know the hazards of the contents and follow appropriate safe use practices for the material inside.
- Be familiar with the different types of compressed gasses and various hazards associated with the gasses to be used or applied in the Appendix B: Compressed Gas Safety Reference Guide.
- Consult the Safety Data Sheet (SDS) for all gases used. Some gases are pyrophoric (i.e., phosphine), corrosive (i.e., hydrogen chloride), toxic (i.e., ethylene oxide), anesthetic (i.e., nitrous oxide), or highly reactive (i.e., anhydrous ammonia).
- Note: If you are unsure on how to control dangerous properties of a compressed gas, call EHS at (949) 824-6200.
- 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. Do not use a cylinder with unidentified contents. Don't rely on stenciling or color of the cylinder.
- Don proper personal protective equipment such as safety goggles, gloves, lab coats, long pants, and steel- toe or closed-toe shoes and consult with EHS for assistance, if necessary.
- Know the location of your emergency eyewash and showers, fire extinguishers, and evacuation routes.

5.2 Gas Cylinder Storage & Transport

5.2.1 Secure

- Secure gas cylinders to prevent falling due to accidental contact, vibration, or earthquakes. Cylinders are secured in one of the following ways:
  - By a noncombustible, two-point restraint system (i.e., chains) that secures the cylinder at the top and bottom one-third portions.
  - By a noncombustible rack, framework, cabinet, approved strapping device, secured cylinder cart, or other assembly that prevents the cylinder from falling.
- Ensure gas cylinder securing systems are anchored to a permanent building member or fixture. Connect these systems to a permanent building fixture to prevent movement during a seismic event.

5.2.2 Store

- Safeguard cylinders whether empty or full and properly store them with their caps on, upright and secured by chains, straps or in racks to prevent them from falling.
- Protect all cylinder storage areas, outside or inside, from extreme heat, not exceeding 125 degrees Fahrenheit, and cold and from access by unauthorized personnel.
- Eliminate obstructions to exits or routes of egress at storage of compressed gas cylinders. Also, compressed gas cylinders shall not be stored near elevators, walkways, platform edges, or in locations where heavy moving objects may strike or fall upon them.
- Maintain sufficient ventilation where portable cylinders are being stored. 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.
- Provide emergency power for exhaust ventilation, gas-detection systems, emergency alarm systems, and temperature control systems.

5.2.3 Segregate

- Physically segregate incompatible contents. For example, flammable gases must be stored separately from oxidizing gases.
- Store and use cylinders that are distanced 20 feet away from each other or by a 5-foot high, one-hour fire-rated wall.
- Store full and empty cylinders in separate areas**.** Label or tag empty cylinder at 25 psi; never empty the cylinder all the way to zero.

5.2.4 Transport

- Protect compressed gas cylinder valves with the protective cap on during transport.
- Move cylinders on chain equipped hand trucks or carts; never roll or drag a cylinder
- Transport liquefied fuel-gas cylinders in an upright position so that the safety relief device is in direct contact with the vapor space in the cylinder at all times.

5.3 Gas Withdrawal and Transfer

- Keep cylinders with regulators upright, attached to the wall or a sturdy structure.

Only install regulators that are compatible with the compressed gas in the cylinder. Check the CGA number indicated on the regulator and cylinder valve. Do not tamper with the CGA fitting that could cause cross-contamination between gases. For more information on cylinder valves and regulator, refer to Appendix A: Compressed Gas Cylinder Valves and Regulators

- There is no need to use plumbers' tape or Teflon tape, lubricants or grease to assist in the fit of the regulator-valve connection. Metal to metal fit is necessary to prevent damage to the threads and seating.
- Open cylinder valves slowly, directed away from your face. If a cylinder valve cannot be opened, the valve should never be forced. 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.

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

5.4 Precautions for Specific Gas Hazards

- 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 should be handled with clean hands and tools.
- Oxidizing gases such as compressed oxygen or nitrous oxide, while not combustible themselves, will cause many materials to burn violently. Avoid using grease, solvents, or other flammable material on an oxygen valve, regulator, or piping.
- 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.
- Any space where cryogenic fluids may accumulate (consider leakage into enclosed equipment) should 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.

5.5 Emergency Procedure

- It is not recommended to conduct your own repair of any cylinder leaks. If handling of a leaking cylinder could be done in a safe manner, move the cylinder in a well-ventilated and isolated area away from any combustibles, ignition sources, and other flammable materials.
- If a leak becomes uncontrollable and there is risk of hazardous material release, call 911 and stay on the call until first responders arrive at the scene.
- Have the supplier or vendor contact information available to provide to first responders.
- Emergency evacuation and response procedures should be put in place and practiced with regular frequency.

6. Reporting Requirements

Employees are encouraged to report any safety concerns to their supervisor or to EHS via safety@uci.edu, (949) 824-6200, or anonymously via https://www.ehs.uci.edu/forms/report-injury/index.php.

7. References & Appendices

Title 8 California Code of Regulations, General Industry Safety Orders -

§3301, §3304, §4649, §4650

National Fire Protection Agency (NFPA) 45, 8-1.5

Compressed Gas Association

American National Standards Institute (ANSI)

Appendix A: Compressed Gas Cylinder Valves and Regulators

Appendix B: Compressed Gas Safety Reference Guide

Appendix A: Compressed Gas Cylinder Valves and Regulators

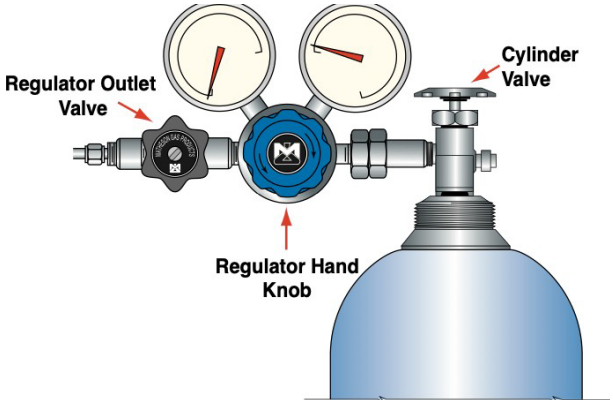


Figure 1. Components of gas cylinder and regulator assembly

Cylinder valves:

The cylinder valve is the primary safety component of the gas cylinder and must not be tampered with. The valves allow the gas cylinder to contain the cylinder contents. However, they are the most fragile and vulnerable part of the whole compressed gas package.

Valve outlet threaded:

To prevent the connection of the incorrect regulator to the cylinder valve outlets, flammable and non-flammable gases have opposite hand threads as shown below:

The conventional right-hand threads for non-flammable, non-toxic gases.
For example: oxygen, nitrogen, argon, air

The notched valve outlets for flammable gases are screwed LEFT-HAND (counter-clockwise)
For example: hydrogen, acetylene, propane

Figure 2. Non-flammable vs flammable gas threads

Some valves are fitted with different type of pressure relief valves, burst disk, and integrated regulator to prevent catastrophic failure of the cylinder valve as shown in figure 3.

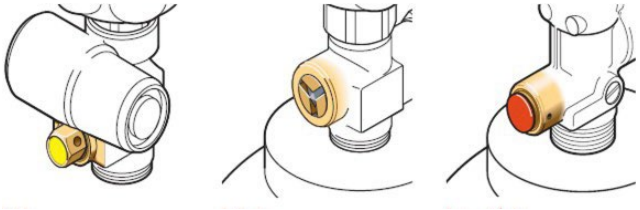


Figure 3. From left, burst disk, fusible plug and pressure relief valve

Regulators:

The gas regulator is the most important safety component to control the high pressure of the cylinder content. It is used to decrease the high pressure to a stable and useable pressure. They are designed to use for specific gas and pressure set point.

The Compressed Gas Association (CGA) has developed a system by designing different size and type of connection fitting to prevent using incompatible regulator or a compressed gas cylinder.

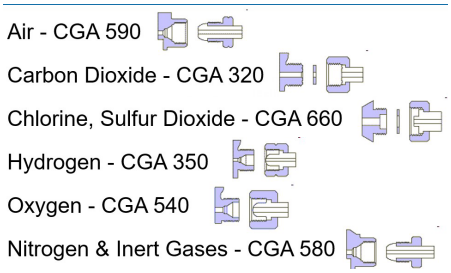


Figure 4. Commonly used CGA connection on campus

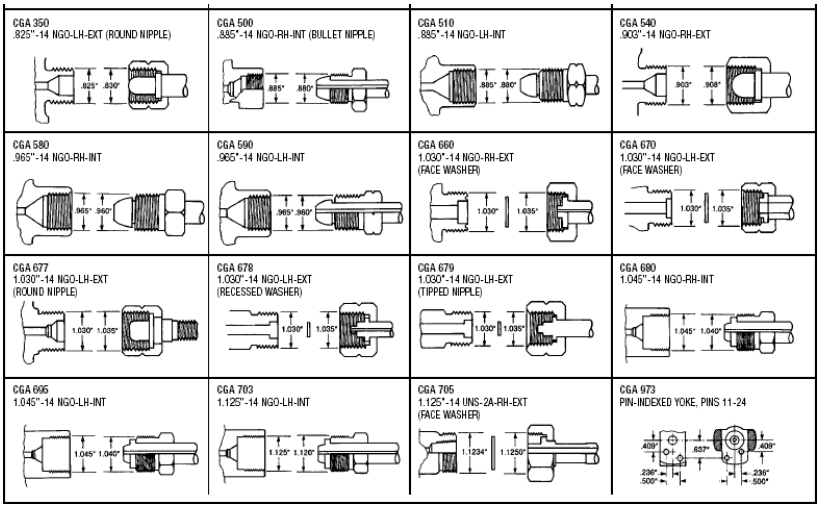


Figure 5. Illustrates the details in size, thread and washers for different CGA number to prevent cross contamination.

Appendix B: Compressed Gas Safety Reference Guide

UCI Environmental Health & Safety

Issued: May 2020

Compressed Gas Safety

REFERENCE GUIDE

Compressed gas cylinders encompass a wide class of hazards-both physical and chemical. Due to high pressure inside the cylinders, they can be propelled with force that can cause extreme injury. Even with the pressure contained, the sheer weight of the cylinder can be dangerous to the body and as it will be discussed below, different gases may have several hazardous chemical properties.

Types of Compressed Gases

Non-liquefied	also called compressed gases or permanent gases. They do not become liquid when they are compressed at normal temperatures, even at very high pressures. Examples: Oxygen, Nitrogen, Helium, Argon
Liquefied	can become liquids at normal temperatures inside cylinders under pressure. Examples: Anhydrous Ammonia, Propane, Butane, Propylene, Carbon Dioxide
Dissolved	chemically very unstable and can explode even at atmospheric pressure. The cylinders are usually packed with inert, porous filler saturated with acetone or other suitable solvent. Examples: Acetylene
Cryogens	are liquefied gases that are kept in their liquid state at very low temperatures. These gases must be cooled below room temperature before an increase in pressure can liquefy them, and therefore have two properties in common: they are extremely cold, and small amounts of liquid can expand into very large volumes of gas. Examples: Liquid Oxygen, Liquid Nitrogen

Hazards of Gases

Flammables – gases that ignite on contact with heat source.

Asphyxiants – gases that displaces oxygen in the air (less than 19.5% of oxygen) causing suffocation.

Oxidizers – gases that react with oxygen and oxidizing gases to produce heat or an explosive reaction.

Toxics – poisonous gases.
*Must notify Campus Fire Marshall or EH&S prior to purchase of toxic/poison gases.

Pyrophorics – gases that spontaneously ignite on contact with air.

Corrosives – gases that cause skin or eye burns or irritation on contact or exposure.

*Many gasses carry multiple hazards. Know all applicable gas hazards beyond the cylinder labeling.

Dry Ice

- Sublimates directly to CO_2
- Can displace oxygen
- Use in well ventilated areas
- Wear PPE and avoid skin contact

Personal Protective Equipment

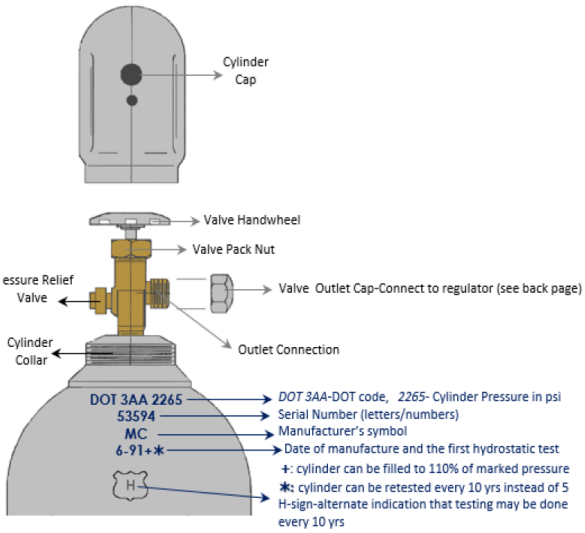
Eye and face protection
- Safety Glasses or Goggles
- Face Shield

Non-absorbent, loose fitting gloves
- Leather Gloves
- Cryogenic Gloves

Proper clothing
- Long Sleeve Lab Coat/Apron
- Long Cuff-less Pants

Closed-toed shoes
- Steel-toe Shoes

Cylinder Anatomy



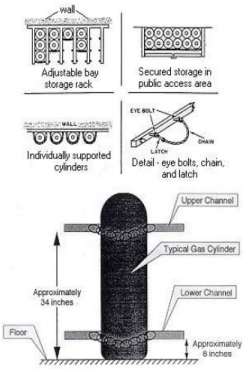
Compressed Gas Self-Inspection Checklist Tool:

Pre-use

- ☐ Don on proper personal protective equipment such as safety goggles, gloves, lab coats, long pants, and steel-toe or closed-toe shoes.
- ☐ Cylinder labels are in place and legible.
- ☐ The cylinder has been periodically tested by the manufacturer or vendor.
- ☐ Read the Safety Data Sheets (SDS) to become familiar with the hazards of the contents of the cylinder.
- ☐ No visible damage on the cylinder such as dents, corrosions, or burns.
- ☐ No tear on any tubing or hoses or damage to the regulators.
- ☐ Know the location of your emergency eyewash and showers, fire extinguishers and evacuation routes.

Storage

- ☐ Cylinder caps are in place when not in use.
- ☐ Cylinders are stored upright in racks or double chained.
- ☐ Cylinders are secured with non-combustible material, such as chains or metal racks, on the bottom and top third of its height.
- ☐ Cylinders are not blocking or obstructing any exits or pathways.
- ☐ Cylinders are stored away from excessive heat, continuous dampness, corrosive chemicals instead store in dry, cool, well-ventilated areas.
- ☐ Separately store incompatible gases such as,
  - Oxygen and fuel gases (minimum of 20ft distance or separated by fire-resistant partition);
  - Corrosive gases and flammable substances such as gasoline, oil
  - Full and empty cylinders.
- ☐ Empty cylinders are labeled or tagged. The cylinder is considered empty at 25psi; never empty all the way to zero.
- ☐ Place toxic and corrosive gas cylinders in approved cabinets.

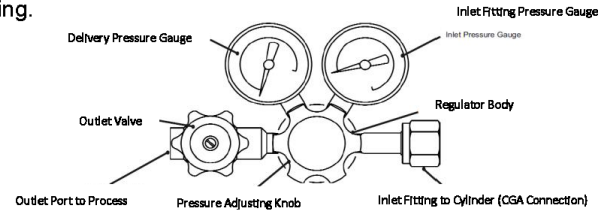


Transport

- ☐ Ensure the regulator is detached.
- ☐ Valves are tightened, closed, and covered with cap.
- ☐ Use proper material handling equipment such as hand carts with chain links to secure cylinders when transporting even at short distances.
- ☐ Keep the cylinder close to upright position not horizontal.

Regulator Installation

- ☐ Use an approved regulator wrench when opening and closing valves.
- ☐ Install regulator with compatible pressure rating and gauge range and only install with correct CGA fitting.



- ☐ Ensure there is no debris, grease, or contaminant in the cylinder outlet connection.
- ☐ Inspect for damage to the regulator CGA connection.
- ☐ If the CGA connector of the regulator is designed to have a washer, replace with new washers when changing cylinders.
- ☐ The regulator is tightly connected without any use of a plumbers tape.
- ☐ Once the regulator is installed, close the outlet valve before slowly turning on the valve to a turn and a half.
- ☐ Apply leak-detection liquid (such as Snoop) to find leaks.
- ☐ Turn the pressure adjusting knob until it reach the desired pressure.

In case of a cylinder leak:

- Never conduct your own repair of any cylinder leaks. If handling of a leaking cylinder could be done in a safe manner, move the cylinder in a well-ventilated and isolated area away from any combustibles, ignition sources, and other flammable materials.
- If leak becomes uncontrollable and there is risk of hazardous material release, call 911 and stay with on the call until the first responders arrive at the scene.
- Have the supplier or vendor contact information to provide to the first responders.
- Emergency evacuation and response procedures must be put in place and practice.

Compressed Gas Safety

REFERENCE GUIDE

I have reviewed and understand the contents of this document.

Name (print)	UCInetID	Signature	Date