General Assistance

Office of Environment, Health & Safety	642-3073

Emergency Phone Numbers

Emergencies:		
Life-threatening Emergency or		
Imminent Hazard to the Environment		911
From cell phone		642-3333
Non Emergencies:		
Chemical or Biological Spill, or Radioactive		
Materials Spill/Business Hours	EH&S	642-3073
Off-hours/Weekend Spills	UCPD	642-6760
Physical-Plant Campus Services (24 hours)		642-1032

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Compressed Gas Cylinders: Proper Management And Use

University of California, Berkeley
Office of Environment, Health & Safety

Contents

Introduction

University of California, Berkeley (UC Berkeley) departments that use compressed gas cylinders must comply with a wide variety of laws and regulations, including those issued by Cal/OSHA, the California Fire Code and the City of Berkeley. This booklet provides general guidelines to help departments comply with those regulations. More specific information can be obtained from Material Safety Data Sheets and your department's Job Safety Analyses (JSAs). Talk to your gas supplier about hands-on training and other useful safety information.

Compressed gas cylinders range from small lecture bottles to large cylinders with more than 200 cubic feet of gas. Before using a compressed gas cylinder ("cylinder"), users and handlers must be familiar with general and specific hazards associated with it. There are many different types of gases, including atmospheric gases, welding gases, fuel gases, refrigerant gases, toxic gases, and calibration gas mixtures.

1.0 General Hazards

All compressed gases present physical hazards due to their high pressure. Inert and non-flammable gases (e.g., nitrogen, helium) may displace air, causing an oxygen-deficient atmosphere that can result in unconsciousness or death. Using corrosive, reactive and toxic gases poses chemical hazards, while flammable gases pose fire and explosion hazards. A gas may have multiple hazards, such as hydrogen chloride, which is both corrosive and toxic.

How each gas can harm you should be fully understood prior to using it. Can it poison me? Will it displace oxygen? Can it catch fire and explode? Hands-on training should be provided by a trained and knowledgeable gas user or the gas vendor.

2.0 Think Before You Buy

Refillable gas cylinders are supplied by gas vendors and usually must be returned to the vendor when they are empty or no longer needed. **By renting refillable cylinders rather than purchasing them outright, you will minimize storage hazards and disposal costs.** Go to the Business Services web site (*http://supplychain.berkeley.edu/buying/buying-goods/gas-compressed-toxic*) for information on how to order gas and return empty cylinders through the campus compressed gas vendor.

Non-refillable, non-returnable gas cylinders, such as lecture bottles and propane tanks, are purchased from the gas vendor and are generally not returnable. **Lecture bottles** are small, non-refillable compressed gas cylinders, typically 2-3 inches in diameter and 12-18 inches in height. The Office of Environment, Health & Safety (EH&S) discourages buying non-returnable cylinders if other options are available. Ask vendors for a complete list of gases available in returnable cylinders (they are almost as portable as lecture bottles and cost less when considering potential disposal costs). Full, partially full and empty cylinders that cannot be returned to the supplier must be disposed of through EH&S. Cylinder disposal can be very costly, so think before you buy!

Before ordering **toxic gases**, you must contact EH&S for a hazard evaluation and written purchase approval. Refer to the "EH&S Campus Toxic Program Fact Sheet" (*http://ehs.berkeley.edu/sites/default/files/lines-of-services/workplace-safety/32toxgas.pdf*) for a list of 48 common toxic gases and more information about the program. **Toxic gases** are defined (at UC Berkeley) as gases that cause significant acute health effects at low concentrations, have a National Fire Protection Association (NFPA) health rating of 3 or 4, or have low occupational exposure limits.

3.0 Receiving Compressed Gas Cylinders from the Vendor

Before receiving gas from the vendor, be familiar with the physical, chemical, and toxicological properties (i.e., read the

Material Safety Data Sheet). Inspect all incoming cylinders to ensure they are undamaged and properly labeled. Do not rely on the color of the cylinder to identify the gas. Different suppliers may use different colors for cylinders of the same gas. Be sure cylinders are not giving off odors, visible fumes, or hissing sounds. Check that the cylinder was last hydrostatic pressure tested within the required time (usually five years). Do not accept cylinders that are rusted, unlabeled, mislabeled, or if the valve or fixtures are damaged. Damaged cylinders, and those that do not comply with identification requirements, should be returned to the manufacturer or distributor (see section 12.0).

Cylinder tags available from EH&S

Once accepted, it is a good practice to tag each cylinder to indicate that it is full, and write a date received on it. (An EH&S tag can be viewed at *http://ehs.berkeley.edu/sites/default/files/lines-of-services/workplace-safety/gascylindertag.pdf* and is available upon request).

4.0 Keep Your Chemical Inventory Up To Date

Gases are chemicals and must be included in the EH&S chemical inventory that your laboratory must update when inventories change. Enter the concentration and volume of each compressed gas. If the volume of gas is not known, assume that the cylinder is full. Be sure to remove the cylinder from your inventory when it is removed from your lab.

5.0 Safe Storage Practices

Because of the high internal pressure in compressed gas cylinders, they can become projectiles if stored or transported

in a manner that could damage the valve. Leaking cylinders may displace air, causing an oxygen-deficient atmosphere that can lead to unconsciousness or death. To help prevent serious injury to yourself and others, follow these safe storage practices.

1. Store cylinders in well-ventilated areas. Never store cylinders inside drawers, cupboards or cabinets that are not designed for gases.

2. Areas where flammable gases are stored must have suitable fire extinguishing equipment.

3. Store full cylinders away from sparks, flames, direct sunlight, or hot surfaces.

4. Store cylinders away from corridors, paths of egress, and stairways.

5. Cylinder storage areas must be accessible and uncluttered.

6. When not in use, cylinders must be stored with valve-caps in place. Lecture bottles do not have valve-caps; they need to be stored in a secure manner to prevent valve damage.

Figure 1

7. When storing cylinders in an upright position, prevent them from falling by using two (2) non-combustible restraints (1/3 of the way from top and bottom) such as chains. Attach them securely to a wall, rack or other solid, non-combustible structure. (Securing individually is recommended.)

8. When storing cylinders on their sides, prevent them from rolling by using a rubber stop, rack or other suitable device.

9. Secure lecture bottles in a secure rack. (See Figure 1)

10. For outdoor storage, provide drainage, ventilation, overhead cover, and security.

11. Each regulator valve should be inspected by the user annually for damage.

12. If two labels are associated with one cylinder, affix the labels 180° apart on the shoulder of each cylinder.

13. Close valves on empty cylinders, date them, and label them with an "EMPTY" tag (see *http://ehs.berkeley.edu/sites/default/files/lines-of-services/workplace-safety/gascylindertag.pdf*). Store them separately from full cylinders.

14. Never tamper with cylinders in any way (e.g., repair, repaint, refill, change markings, or interfere with valve threads or safety devices).

15. Do not attempt to extinguish a fire caused by a gas unless you have received training. Shut off gas at the source if safe to do so, pull the fire alarm and call 911 immediately.

16. Some gases lose integrity and the manufacturer may recommend returning the gas after a specific storage time (see MSDS).

17. Cylinders are often heavy. Get help when lifting them, and prevent them from falling or rolling.

For guidance on how to engineer cylinder storage, see EH&S Q-Brace guidelines at *http://ehs.berkeley.edu/sites/default/files/lines-of-services/workplace-safety/qbraceT3.pdf*

6.0 Moving and Transporting Cylinders

Only trained hazardous materials employees are allowed to transport cylinders on public roads (i.e., off campus). If you need to move cylinders off campus, contact EH&S for assistance.

Figure 2

To move a cylinder on campus, remove the regulator if one is attached and secure the protective valve cap. Do not roll or drag a

cylinder or allow cylinders to strike each other or other objects. Always use a suitable cylinder cart (see Figure 2) for transporting cylinders, with the cylinder securely chained or strapped to the cart (see Figure 2). Inspect the cylinder cart and wheels for wear and tear before each use. If you purchase a two-cylinder cart, each cylinder must be restrained by its own chain. Carts are for transporting cylinders, not for storage.

Do not lift or move the cylinder by the cap. Ropes or slings should not be used to suspend cylinders unless the gas vendor has made provisions for such lifting.

Cylinders should be transported in freight/cargo elevators only, and **never** in the passenger compartment of a vehicle. Please refer to the EH&S Fact Sheet titled "Transporting Chemicals Safely on Campus."

7.0 Safe Use

Follow these guidelines to supplement any department-specific safety information and training.

1. Never use a hammer or wrench to open cylinder valves.

2. Stand to the side of the valve outlet when opening the valve.

3. Never refill cylinders or change their contents.

4. Do not use gas cylinders for any purpose other than transportation and supply of gas.

5. Do not tamper with or attempt to repair or alter cylinders or regulators.

6. Most cylinders have one or more safety-relief devices to prevent rupture of the cylinder if internal pressure builds up to levels exceeding design limits. (Some gases

are so toxic that their release through a safety device would be hazardous.) Never tamper with safety-relief devices.

7. Return cylinders to the gas vendor for all repairs. Refer to the manufacturers' recommendations for maintenance.

8. Do not use lubrication of any kind on valve regulators for compatibility issues.

9. Never strike an electric arc on a cylinder. Arc burns can weaken the cylinder.

10. Always secure cylinders with the valve cap, especially when moving them, as they can be projectiles if the valve is damaged.

11. Do not use valve protection cap for lifting the cylinder.

12. If an inert gas cylinder is leaking and the valve can't be closed safely, immediately evacuate, seal off the area, and contact EH&S.

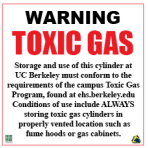
13. If a non-inert gas cylinder is leaking and it poses a danger to building occupants, pull the fire alarm and call 911 immediately.

8.0 Special Precautions for Certain Gases

8.1 Flammable Gases. Flammable gases, such as acetylene, butane, ethylene, hydrogen, methylamine and, vinyl chloride can burn or explode under certain conditions. Acetylene and liquefied gases (e.g., propane) must be stored in a valve-end up position unless specifically designed for horizontal use or storage. Before using flammable gases take note of any ignition or heat sources such as open flames, sparks, static electricity or excessive heat. Hydrogen gas can be ignited easily: the flow of gas through tygon tubing can generate static electricity and cause a fire. Refer to the MSDS for additional precautions such as grounding.

Many flammable compressed gases are heavier than air. If a cylinder leaks in a poorly ventilated area, these gases can settle

and collect in sewers, pits, trenches, basements, or other low areas. The gas trail can spread far from the cylinder, make contact with an ignition source and the fire produced can flash back to the cylinder.



Toxic gas tags available from EH&S

8.2 Toxic Gases. The UC Berkeley campus has special requirements for the use of toxic gases. Examples include ammonia, carbon monoxide, chlorine, and ethylamine. **Before a toxic gas can be purchased, EH&S must perform a hazard evaluation and issue a written purchase approval.** The evaluation explains the conditions that must be followed for the gas to be stored and used safely. A fact sheet on the Toxic Gas Program - which lists 48 common toxic gases - can be viewed at *http://ehs.berkeley.edu/sites/default/files/lines-of-services/workplace-safety/32toxgas.pdf*. The fact sheet has a link to the entire Toxic Gas Program web site.

8.3 Oxygen and Oxidizing Gases. Examples of oxidizing gases include oxygen, nitrous oxide, chlorine, and bromine. They can burn and destroy body tissues on contact. Corrosive, oxidizing gases can also attack and corrode metals. Do not permit organic materials such as oil and grease to come in contact with compressed oxidizing gases. Regulators and tubing used with oxidizing gases must be specially cleaned to remove oil and other reducing agents or explosions may occur. Store oxidizing gases in areas constructed of non-combustible and corrosion resistant materials. Follow other storage requirements by checking the reactivity information contained in the MSDS.

8.4 Corrosive Gases. Examples of corrosive gases include hydrogen chloride, ammonia and chlorine. Periodically check cylinders to ensure that the valve has not corroded or clogged. If a cylinder or valve is noticeably corroded, the gas vendor should be contacted and the gas vendor's instructions followed.

8.5 Dangerously Reactive Gases. Some pure compressed gases are chemically unstable. Common dangerously reactive gases are acetylene, 1,3-butadiene, methyl acetylene, vinyl chloride, tetrafluoroethylene, and vinyl fluoride. If exposed to slight temperature or pressure increases, or mechanical shock, they can readily undergo chemical reactions and result in fire or explosion. Some dangerously reactive gases have inhibitors to prevent these hazardous reactions.

8.6 Pyrophoric Gases. Pyrophorics are materials that will spontaneously ignite upon exposure to air. These are extremely hazardous and must be handled with great care. Examples of pyrophoric gases are silane, disilane, dichlorosilane, diborane (borane) and phosphine.

8.7 Storage of Incompatible Gases. Keep incompatible gas cylinders (> 1.89 liters or 2.27 Kg in capacity) at least 20 feet apart . A non-combustible partition of not less than 18" above and beyond the sides of the cylinders is required if physical separation is not practical.

9.0 Safe Use of Regulators and Valves

Never attempt to attach a regulator to a cylinder without first receiving hands-on training from a knowledgeable user and reading these guidelines. Always wear approved eye protection and other safety equipment as recommended by the MSDS, and make sure the regulator to be used is suitable for the application. Most gas company catalogs give this information for both gases and regulators.

Single-stage pressure regulators reduce the cylinder pressure to the delivery or outlet pressure in one step. Two-stage pressure regulators reduce the cylinder pressure to a working level in two steps. Generally a single-stage regulator is good for short duration applications; a two-stage regulator is good for long duration applications, such as gas chromatography.

10.0 How to Attach a Regulator

Before attempting to attach a regulator to a cylinder, check with your department and gas supplier for any additional requirements regarding the installation of regulators.

1. Use pressure regulators that are equipped with pressure relief devices, if needed.

2. Check the Compressed Gas Association (CGA) approved regulator fitting and the fitting surface of the cylinder valve for damage, especially the threads and seat. Remove any loose debris from the threads and seat and do not use if damaged.

3. Set the pressure of the regulator to zero by turning the adjusting knob or handle counterclockwise. It is important that at least two threads remain engaged into the regulator body.
(See Figure 3)

Figure 3

4. Close the outlet valve fully in a clockwise direction.

5. Tighten the CGA approved connection in a counter clockwise direction. (Hex nuts on the CGA approved connection with notches in the middle are tightened in a counterclockwise direction.)

6. Do NOT force the connection. If you cannot easily make the connection by hand, you are using the wrong regulator or the threads are damaged. CGA approved fittings may be obtained from any gas supplier.

7. Tighten until snug using a regulator wrench, an open end wrench or an adjustable wrench. Do NOT over-tighten.

8.Cylinder connections and fittings are designed to connect without the use of Teflon® tape; Teflon® tape should only be

used on tapered pipe threads where the seal is formed in the thread area.

9. If the regulator requires gaskets on the CGA connection, inspect them for wear or contamination and replace the gasket at each cylinder change out.

10. Use the proper fittings on the outlet of the regulator to the system. The correct fitting can be purchased from the regulator supplier. Do not make adapters to get to the proper fitting.

11. Use a dilute soap solution (available from gas suppliers) to check for leaks where the valve attaches to the cylinder and around all other thread connections. If leaks are discovered, depressurize, tighten, and then recheck the connections.

12. If no leaks are discovered, the operator should position him or herself with the regulator on the opposite side of the cylinder. Slowly open the cylinder valve in a counterclockwise direction, 1/8 turn. The high pressure gauge should rise to full cylinder pressure.

13. Turn the regulator's adjusting knob or handle clockwise to raise the delivery pressure to the desired working pressure while observing the delivery pressure gauge. Do not exceed the maximum delivery pressure for the regulator or the system.

14. Check the system for leaks again as outlined above.

15. Open the outlet valve on the regulator to supply gas to the system. Delivery pressure may need some adjustment.

11.0 How to Shutdown a Cylinder with a Regulator

Be certain that the gas stream is shut off at its source when not in use. Never use a regulator as a shut-off valve.

For temporary shutdown (less than 30 minutes), close the gas cylinder valve completely. For extended shutdowns (more than

30 minutes), first close the gas cylinder main shutoff valve completely. Second, set the pressure of the regulator to zero by turning the adjusting knob or handle counterclockwise, leaving at least two threads engaged into the regulator body. If your system has an outlet control valve downstream of the regulator, open this valve to purge gas from the delivery line and then close it.

12.0 Compressed Gas Cylinder Return or Disposal

In general, a cylinder is considered empty when the cylinder pressure is approximately 30 pounds per square inch (30 psi or about 2x atmospheric pressure). The ability to return a gas cylinder to the vendor when empty or no longer in use depends on whether or not it is **refillable** or **non-refillable**:

1. **Refillable** gas cylinders, (typically ≥ 4" in diameter) are owned by the gas vendor and must be returned when they are empty or no longer needed. If you have a refillable cylinder, follow the campus return procedures (*http://supplychain.berkeley.edu/buying/buying-goods/gas-compressed-toxic*) on the Business Services website.

2. **Non-refillable** gas cylinders (e.g., lecture bottles) must be managed as potential hazardous waste through EH&S.

Testing of unknown cylinder

If you cannot return your unwanted cylinder (empty or partially full) to the vendor, EH&S will pick it up and manage it appropriately. Initiate a pick up by going to *https://jwas.ehs.berkeley.edu/hwp*. EH&S also takes "unknown" cylinders (cylinders containing unknown gases are expensive to test and dispose). EH&S will arrange for the most cost effective and environmentally sound disposal, including possible reuse on campus.

Do not cut cylinders or remove cylinder valves without EH&S approval and training. Removal of valves from lecture bottles can present a significant hazard if the cylinder is not fully discharged. Lecture bottles that held flammable gases may still

present a fire or explosion hazard, while those that held corrosive, poisonous, or reactive gases may still have sufficient residues to present a health hazard. Pyrophorics should never have their valves removed.

13.0 Other Resources

Gas vendors maintain technical data on a wide range of gases, such as the following:

- Matheson TriGas - *http://www.mathesongas.com*
- Scott Specialty Gases - *http://www.scottgas.com*
- Praxair - *http://www.praxair.com*

See EH&S web site for a booklet entitled "Safe Storage of Hazardous Chemicals."

The Compressed Gas Association sells a number of publications on the safe use of compressed gases, regulators and valves. For more information, go to: *http://www.cganet.com*.