

COMPRESSED GASES & CRYOGENS

Compressed gas cylinders and cryogen Dewars must be handled with caution at all times. Assume all cylinders contain gas under pressure and treat all gases as hazardous chemicals. When using gas or cryogenics, make sure to wear closed-toe shoes and safety glasses as a minimum, and tailor personal protective equipment to each hazard.

HAZARDS OF COMPRESSED GASES

Physical and health hazards are present with use of compressed gases.

- The **high pressure** in cylinders (4.4 to 6,000 psig) makes the gas cylinder a potential physical explosive rocket that could punch through walls.
- Some gases may be **corrosive** which could result in change in tissue and/or equipment at the point of contact.
- Cryogenic gases have dangers of low temperature, potential **frostbite**, and they may expand into large volumes of gas that could displace oxygen and result in suffocation.
- Inert gases and oxidizing reactions may create oxygen deficiency hazards by displacing oxygen and may lead to **suffocation**. The early symptoms may be dizziness and weakness, which may lead to unconsciousness and death. This is also termed asphyxiation.
- **Flammability** is a concern especially with the gases acetylene, hydrogen, and propane.
- The permissible exposure limits for toxic materials is very low and so even small exposure is considered to be **poisonous**.
- Oxygen leaks may create oxygen enriched atmospheres which increase the risk of **fire** and **explosions**. Watch a video demonstrating the hazard at <http://youtu.be/ZNiZaVT1mBY>.
- See additional hazards listed on safety data sheet for each chemical.

Compressed gas cylinders must be handled with caution at all times.

It is important to protect cylinder valves from breakage.

Store gas cylinders upright.



GENERAL SAFETY: Do's

1. Make sure cylinders have proper labels including: contents, concentrations, hazard classifications, safety precautions, manufacturer or supplier's name and a tag that indicates whether the cylinder is full, in-service or empty. Accept only properly identified cylinders. If the cylinder is not properly labeled or the label cannot be read, return the cylinder to the supplier.
2. Make sure gas cylinders are not damaged and do not show signs of corrosion. If a cylinder has damaged labels, dents, gouges, burn/heat marks, or shows signs of corrosion, do not accept it and return it to the supplier.
3. Assume all cylinders contain gas under pressure. Treat all gases as hazardous chemicals.
4. Clearly label all gas lines leading from gas cylinders.
5. Use, store and transport cylinders in an upright position unless they qualify to be stored horizontally. (*See Storage section below for more information.*)
6. Use cylinders in a well-ventilated area. If you need to use a gas cylinder in spaces with inadequate ventilation, call EH&S at 206.543.7388 to conduct a hazard assessment. Spaces with inadequate ventilation may need oxygen alarms or ventilation failure alarms.
7. Move cylinders with a cart or hand truck designed for strapping on cylinders.
8. Secure cylinders properly during storage, transport and use so that they cannot be knocked over.
9. Make sure caps are in place when the cylinder is not in use and during transport.
10. Make sure access to the cylinder valve is unobstructed at all times.
11. Make sure pressure regulators are equipped with pressure release valves.
12. When turning off the cylinder, turn the gas supply off at the cylinder valve first, depressurize the system, and turn off the regulator.
13. Keep incompatible gases stored separately. If the cylinder is not in use, separate oxidizing gases

from flammable gases by 20 feet or a one-hour firewall. Note: one backup cylinder stored in the area with the one in use may also be considered "in use" and not subject to incompatibility storage requirements. (*See Compatibility section below for more information.*)

14. Store highly toxic gases in exhausted enclosures (gas cabinet or fume hood).
15. Avoid sources of ignition and open flame.

Personal Protective Equipment (PPE)

When using gas cylinders, make sure to wear closed-toe shoes and safety glasses.

Refrigerated Liquefied Gas/Cryogen PPE:

- Insulated leather gloves
- Protective eyewear and face shields
- Smock or lab coat.

Tailor PPE requirements to each hazard.

GENERAL SAFETY: Don'ts

1. Do NOT purchase more or larger cylinders than necessary.
2. Do NOT store flammable gases next to an exit or near oxygen cylinders.
3. Do NOT use or permit contact with oil or grease on cylinders or their valves.
4. Do NOT empty gas cylinders to a pressure lower than 25 psi (172 kPa). At lower pressures, suction and backflow can cause contamination of residual contents with air if the valve is open.
5. Do NOT use Teflon® tape on cylinder or tube fitting connections, which have metal-to-metal face seals or gasket seals.

PRESSURE REGULATORS

Pressure regulators lower the gas pressure to a useable level.

There are two types of pressure regulator designs which appear similar: single and two stage.

- Single stage regulators are used when precise control of delivery pressure is not required.
 - Two-stage regulators give precise control of delivery pressure.
1. Keep regulators clean, free of surface oil and grease. (Especially oxidant gases).
 2. Always use the proper regulator for the gas in the cylinder. Connection fittings, stamped CGA numbers, plaques and/or decals on the regulator indicate for which gas the regulator is designed.
 3. Do not use Teflon® tape, putty, or other such materials on the threads unless specifically required (or applied) by the manufacturer or vendor.
 4. A volume restriction orifice installed downstream of the regulator is required for all toxic and highly toxic gases. Specify pressure and flow requirements when ordering compressed gas so that the vendor provides the proper restriction orifice.

Securing Cylinders

In Place

Secure the container with a bracket, chain, strap or other approved restraint to a fixed object, such as a wall or bench. Use one or more restraints.

- One strap or chain meets the minimum requirement.
- Two straps or chains at 1/3 and 2/3 of the cylinder height above the floor are recommended because cylinders secured by a single strap have been found to escape the strap during an earthquake.

In Motion

Secure the container to a cart, hand truck or other transport device designed for the movement of compressed gas containers, cylinders or tanks.

STORAGE

1. The cylinder must be in good condition with an operable valve. Cap cylinders not in use.
2. Compressed gas cylinders should be stored in an organized, ventilated and well-lit place away from combustible materials.
3. All gas cylinders must be stored upright and firmly secured to a wall. (*Refer to the Securing Cylinders box for more information*).
4. Do not remove or damage manufacturer applied labels, decals or cylinder content information. If the label is no longer legible, contact the vendor for pickup, or contact EH&S at 206.616.5835 for more information.
5. Any storage area must be protected from excessive heat, open flame or ignition sources.
6. Storage outside should be above grade, dry and protected from weather conditions.
7. Store cylinders so oldest products get used first.
8. Compressed gas containers, cylinders and tanks must be stored in the upright position.

There are two exceptions:

- Containers designed for use in the horizontal position
- Compressed gas containers with a water volume of less than five liters

A lecture gas cylinder is an example of a cylinder that may be stored horizontally.

Compatibility

Gas types should be separated from incompatibles and the areas marked. Guidelines are as follows*:

- Keep incompatibles a distance away of not less than 20 feet or use noncombustible partitions extending not less than 18 inches above and to the sides of the containers, cylinders, or tanks
- Use approved storage cabinets or exhausted enclosures

* **Exception includes:** cylinders in use including one spare backup cylinder stored in the same location as the cylinder in use.

More information from EH&S about compatibility is available on the EH&S website at <https://www.ehs.washington.edu/chemical-compatibility-chart>.

Consideration should also be given to using compatible materials for containers, tubing and reaction vessels. Several compatibility guides are available on the Web, such as www.graco.com/content/dam/graco/ipd/literature/misc/chemical-compatibility-guide/Graco_ChemCompGuideEN-B.pdf.

Toxic Gases

- Store highly toxic gases in exhausted enclosures such as a gas cabinet. A chemical fume hood may be acceptable for lecture cylinders and other small bottles. Contact EH&S for more information.
- A respirator may be necessary when working with toxic and highly toxic gases.
- A volume restriction orifice installed downstream of the regulator is required for all toxic and highly toxic gases. Specify pressure and flow requirements when ordering compressed gas so that the vendor provides the proper restriction orifice.
- ALL toxic and highly toxic gases should be purchased through the University's approved vendor (currently Praxair), unless they do not offer the material. Ordering information is provided on the UW eProcurement Web page.
- Special Fire Department permits and engineering controls such as a gas storage cabinet may be required to use toxic or corrosive gases. Prior to ordering these gases, contact EH&S at 206.543.7262 for an assessment and to ensure proper safeguards are met.
- Extra precautions must also be documented in your standard operation procedures (SOPs) for toxic chemicals.

Flammable Gases

- Store and use flammable gas cylinders in adequately ventilated areas and away from all sources of ignition.
- Avoid using flammable gases that are heavier than air in basements or other areas where vapors can accumulate.

Oxygen and Oxidizing Gases

- Oxygen leaks may create oxygen enriched atmospheres which increase the risk of fire and explosions. Watch a video demonstrating the hazard of oxygen rich environments at <http://youtu.be/ZNiZaVT1mBY>.
- Oxidizers react explosively with flammable gases; they must be stored separately.

Oxygen Depletion

Most compressed gases can create oxygen deficiency hazards by displacing oxygen, which may lead to suffocation. Early symptoms of suffocation may be dizziness and weakness, which may lead to unconsciousness and death. This is also termed asphyxiation.

Cryogenic Liquids

- In addition to other hazards, the nature of cryogenics increase hazards related to expansion rate. Because they are so highly compressed they may expand into large volumes of gas that could displace oxygen and result in suffocation.
- Cryogenic gases have dangers of low temperature, with potential frostbite.
- Proper PPE is even more critical when working with cryogenics. Users should always wear:
 - Insulated leather gloves
 - Protective eyewear and face shields
 - Smock or lab coat
 - Closed toe shoes or boots

Dissolved Gases

Highly unstable gases may be dissolved in a liquid to make them safer for use and transportation. The most common of these is acetylene.

GAS PIPING GUIDELINES

- Piping can suffer pressure changes, depending on the ambient temperature, resulting in an over-pressurization. Piping must include a pressure relief device.
- Pipes must be labeled in accordance with ASME A13.1 to include the content name and the direction of flow not less than every 20 feet, at each valve, at each change of direction, and where it penetrates a wall or floor/ceiling assembly.
- Piping systems should include zone shut-off valves, point-of-use valves, regulators and pressure relief valves to venting lines between regulators and shut-off valves.
- Do NOT use copper fittings and tubing on acetylene tanks.



Permanent Piping Systems

- Many gas piping systems require a permit from the city or county prior to installation.
- The systems must be installed by qualified personnel.
- Piping must be of durable and heat resistant materials compatible with the gas. This may include steel, copper or stainless steel tubing/pipe.
- Fuel gas Grade T flexible gas tubing with appropriate hose clamps must be used for all petroleum-based products.

Temporary Piping Systems

Temporary gas piping systems may be used for short term experimental process development, but it must meet the following conditions:

- Piping/tubing runs should be as short as possible.
- Piping should be visible (i.e., not hidden within walls).
- It must be appropriately labeled with the material and direction (tape may be used if writing is legible).
- Piping may not serve other rooms; it is for local use only.
- Piping material must be compatible with gas; appropriate plastic and soft copper tubing may be acceptable depending on the gas.
- Regulators must step down pressure significantly for piping system.
- Tubing/piping may not be charged (pressurized) when unattended.
- Only experienced lab staff should operate the system.
- Flammability is a concern especially with the gases acetylene, hydrogen and propane. Take necessary precautions.

For questions about compressed gas and cryogen safety, contact EH&S at 206.543.7262.