

GASES UNDER PRESSURE HAZARDS & RISK MINIMIZATION




Background


The United States Occupational Safety and Health Administration (OSHA) defines “Gases under Pressure” as gases that are contained in a receptacle at a pressure of 200 kPa (gauge) or more at 20°C, or at which are liquefied or liquefied and refrigerated.

OSHA lists four groups:

- Compressed gases (e.g., hydrogen)
- Liquefied gases (e.g., propane, anhydrous ammonia)
- Refrigerated liquefied gases (e.g., liquid nitrogen)
- Dissolved gases (e.g., acetylene)

Gases under pressure will be identified with the pictogram shown in the chart below. In addition, the label and Safety Data Sheet (SDS) will include the following signal words and hazard statements.

Hazard Category	Pictogram	Signal Word	Hazard Statement
Compressed Gas		Warning	Contains gas under pressure; may explode if heated
Liquefied Gas		Warning	Contains gas under pressure; may explode if heated
Dissolved Gas		Warning	Contains gas under pressure; may explode if heated

Refrigerated Liquified Gas		Warning	Contains refrigerated gas; may cause cryogenic burns or injury
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Improper handling of compressed gas cylinders can result in adverse physical or health effects. In addition to general procedures for handling and using compressed gases, certain facility related requirements will apply depending on the type and amount of gases in use.

Hazards

Several different hazards are associated with the “Gases Under Pressure” classification, with the common primary hazard of all GHS groups being high pressure contained in the cylinder. Gases in high-pressure cylinders contain an extraordinary amount of stored energy. If a cylinder valve is breached (i.e., breaks off when the cylinder falls and strikes a hard surface, etc.), the stored energy in the cylinder is released as thrust. The cylinder can accelerate to speeds great enough to penetrate concrete walls. The pressure in a cylinder will increase when subjected to increased temperatures. Cylinders are designed with a pressure relief valve, but if this valve fails then the cylinder can fail. Caution is needed to ensure that systems and apparatus used with compressed gas cylinders are not over-pressurized, which could lead to forceful rupture and flying fragments.

When released from the confines of a cylinder, gases will expand to occupy several hundred or even a thousand times the space. This can displace breathing air and result in an oxygen-deficient atmosphere and a person can be overcome quickly and without much warning.

If a gas is cryogenic (extremely cold), it can cause brittle fracture of components and freeze skin or mucus membranes upon contact.

Depending on the gas, additional chemical physical and health hazards are also possible including but not limited to: flammable, toxic, corrosive, oxidizing, pyrophoric, asphyxia. These additional hazards are covered in other EHS SOPs. The primary focus of this SOP is on the hazards associated with the cylinder pressure.

Mitigating the Risks of Gases Under Pressure

First and foremost, verify that a written, comprehensive project-specific hazard analysis/risk assessment with additional oversight is not in order, as described in the companion EHS SOP,

Chemical Hazard Assessment & Risk Minimization. General risk mitigation measures are as follows:

- Prior to ordering and receiving any gas, review the SDS and other literature from the manufacturer and Compressed Gas Association (CGA) to: (1) acquaint yourself and other laboratory personnel with the hazards posed by the gas; (2) assess ancillary systems, equipment, and piping to ensure that the gas is compatible; (3) determine if the intended use location is adequately equipped to safely use the gas.
- Order the smallest feasible cylinder size, and, if possible, avoid the purchase of nonreturnable cylinders. Do not allow cylinders to sit around for long periods of time. Signs of cylinder/cylinder component deterioration may not be obvious.
- Conduct a search for additional relevant safety information for the gases to be used. For example, the following web sites provide a wealth of information on hydrogen safety:
 - The U.S. Department of Energy Hydrogen Program, led by the Hydrogen and Fuel Cell Technologies Office (HFTO)
 - H2 Tools, built and maintained by Pacific Northwest National Laboratory with funding from the DOE Office of Energy Efficiency and Renewable Energy's HFTO.
- As applicable, consult the following archive sessions of the EHS Laboratory Safety Colloquium series, available on the EHS Web Page as a training resource.
 - Flammable- Corrosive-Toxic Gas Safety
 - Cryogenic Safety
 - Compressed Gas Safety
- If using cryogenics, review the EHS SOP, ***Cryogenic Material***.
- If using liquefied petroleum gas, review the EHS SOP, ***Liquefied Petroleum Gas (LPG) Portable Cylinders***.
- Use and storage locations should be mechanically ventilated (preferably with exhausts located low and high since gases have differing densities), free of combustible materials, away from open flames (25' separation distance), and protected from ambient temperature that could exceed 125° F. In addition, cylinders should not be stored in contact with pooled water or corrosive atmospheres (to prevent corrosion and damage to the cylinder), and away from areas where they could become part of an electrical circuit.



- Understand the dangers of pressurized systems, physical and health hazards of the particular gas in use, and proper installation, specifications, and use of fittings, valves, regulators, and other ancillary equipment. Use only equipment and apparatus that are designed for use in pressurized conditions and that are rated for the appropriate maximum pressure, and designed for the specific gas in use. Ensure that fittings and tubing are compatible with the gas and designed for that use. For example, copper fittings are incompatible with acetylene and can form explosive deposits; standard hose clamps do not take the place of compression fittings. Oxidizing gases are particularly hazardous when in contact with oil, grease, or other organic substances.
- Do not use a compressed gas cylinder unless the cylinder is clearly marked or labeled with the cylinder's content. Never rely on the color of a cylinder to identify its contents.
- Piping systems should be marked with the name of the gas and direction of flow arrows. Marking should be at each critical process control valve, at each wall, floor, or ceiling penetration, at each change of direction, and at every 20' of continuous piping run.
- Always wear appropriate PPE. See EHS SOP, ***Personal Protective Equipment for Chemical Exposures***.
- Use a hand-truck specifically designed to move cylinders. Strap the cylinder onto the hand truck before moving and ensure that the cylinder valve cap is securely in place before moving (do not attempt to move a cylinder with the regulator attached or valve cap removed). Do not roll cylinders or permit them to drop.
- During use and storage, secure full and empty cylinders from tipping over and in an upright manner (some small lecture-size cylinders can be stored horizontally, if approved by the manufacturer).
- If storing multiple cylinders, segregate incompatible gases (refer to Figure 1). Storage of spare cylinders at each point of use in a laboratory is limited to one (1).
- Do not store cylinders next to egress doors or hallways.
- Do not remove the cylinder valve cap until the cylinder has been secured at the point of use. Securing means to use a rack, cage, strap or chain securely affixed to an immovable



object (e.g., wall, counter, etc.). If a strap or chain is used it should be positioned above the midpoint but below the shoulder of the cylinder.

- After removing the cylinder valve cap, inspect the valve assembly for damage. Hand pressure should be all that is necessary for cylinder caps and hand wheel supply valves; tools should not be necessary or used to remove caps or open valves. Return the cylinder to the manufacturer if damage is noted. Do not use the cylinder.
- Inspect ancillary connections, valves, regulators, tubing, and other devices used with compressed gases regularly (including leak testing each time a cylinder is changed). Replace when signs of damage or deterioration are noted.
- All compressed gas cylinders must be used with a regulator that is designed for the gas and pressures involved. Two-stage regulators are generally recommended for laboratory operations.
 - Never use an adapter between the regulator and the source cylinder.
 - Never use an aid, such as pipe dope or Teflon tape to connect a regulator to a cylinder.
- After attaching a pressure-reducing regulator to a compressed gas cylinder:
 - (1) Turn the regulator adjustment screw out (counterclockwise) until it feels loose.
 - (2) Stand behind the cylinder with the valve outlet facing away from you.
 - (3) Observe the high-pressure gauge on the regulator from an angle; do not pressurize a gauge while looking directly at the glass or plastic faceplate.
 - (4) Open the valve handle on the compressed gas cylinder S-L-O-W-L-Y, until you hear the space between the cylinder valve and regulator gently fill the gas. (You can also watch the pressure rise on the high-pressure gauge. If you turned the regulator adjustment screw back properly, there should be no gas flow out of the regulator or pressure rise on the low-pressure gauge.)
 - (5) When you are ready to use the compressed gas cylinder, fully open the cylinder valve until you feel it stop. Then, close it one-quarter turn.
 - (6) Verify that leaks are not present with an electronic detector, soap solution, or other suitable means. Never use a flame to check for leaks.

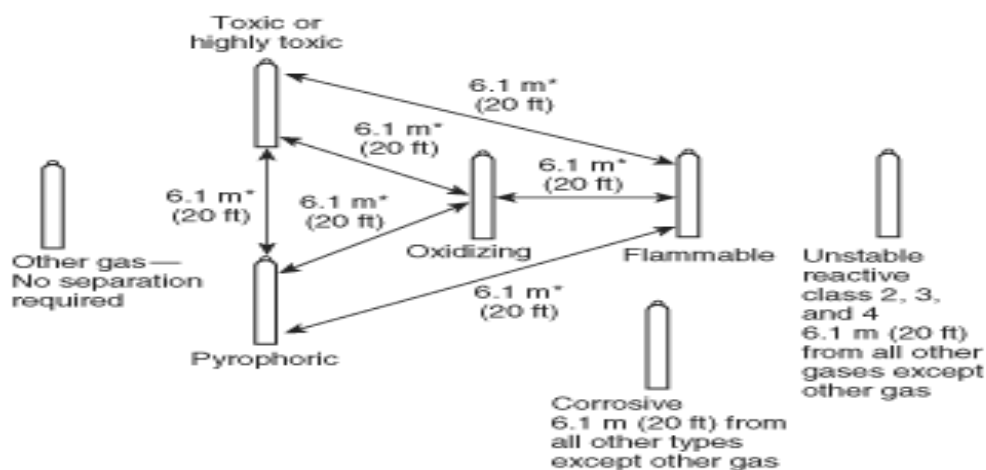
- (7) If using a cylinder that does not come equipped with a hand wheel operated valve, leave the wrench that is used to open the cylinder in place while using the cylinder to allow for quick closing in the event of a leak.
- Use backflow check valves where incompatible gases are connected to a common piece of equipment, or where low- and high- pressure gases are connected to a common set of piping. Use a flame arrestor when using flammable and oxidizing gases in applications where there is potential for flashback.
 - Always close the cylinder valve of an apparently empty cylinder before disconnecting the regulator; and when the cylinder is not in use. Do not leave pressure on the regulator when the cylinder is not in use.
 - Mark all empty cylinders as "empty" or "MT." Secure the valve cap on all stored full or empty cylinders. Ensure that the cylinder valve on empty cylinders is closed.
 - Use only non-sparking tools with flammable gas systems.
 - Do not purposely vent a cylinder. Should there be a suspected leak, close all regulator valves and tighten the packing nut. If the leak continues, initiate the following procedures:
 - If the leak is minor, secure the cylinder next to the fume hood.
 - If the leak is major and presents an imminent hazard, initiate building evacuation and standard emergency procedures as described on the "Safety at Nebraska" web site (<https://safety.unl.edu/>) and in the EHS Emergency Preparedness web-based training (available as a web-based module on the EHS web site).
 - Notify the supplier (if local).

Facility Requirements

- A continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure is required for the **storage and use** of *lecture sized bottles* of the following types of gases:
 - Gases that have a National Fire Protection Association (NFPA) health hazard rating of 3 or 4

- Gases that have an NFPA health hazard rating of 2 without physiological warning properties
- Pyrophoric gases
- At a minimum a continuously mechanically ventilated gas cabinet is required for the above gases in cylinders that exceed lecture-bottle size. The gas cabinet must be sprinklered if the gas is pyrophoric.

Figure 1 – Compatible Gas Storage (Separation)



* The 6.1 m (20 ft) distance can be reduced without limit when separated by a barrier of noncombustible materials at least 1.5 m (5 ft) high that has a fire-resistant rating of at least ½ hour.

Gas storage requirements:

- Separation between flammable and oxidizing, pyrophoric or toxic/highly toxic gases is 20 ft.
- Separation between oxidizing and pyrophoric or toxic/highly toxic gases is 20 ft.
- Separation between pyrophoric and toxic/highly toxic gases is 20 ft.
- Separation between unstable reactive class 2,3, and 4 or corrosive gases is 20 ft from all other gases is required except for “other” gas
- “Other” gas requires no separation