Handling and Storing Compressed Gas Cylinders

1. Purpose

To provide instruction on how to properly and safely handle and store compressed gas cylinders

2. Scope

Applies to everybody handling and storing compressed gas cylinders.

3. Prerequisites

WHMIS and EHS113 Compressed Gases Safety Training

4. Responsibilities

Principal investigators: are responsible for enforcing this SOP, ensuring that all gas cylinders are used, stored, and transported according to applicable legislation and guidelines, and providing training to cylinder users. They are also responsible for ensuring that the right regulators are provided and maintained/serviced when needed, that the cylinders are in good condition, and that the proper storage is provided.

Lab-personnel: are responsible for being aware of hazards associated with compressed gasses, following this SOP, and receiving appropriate training prior to handling compressed gasses. They are also responsible for checking cylinder and regulator conditions, and for handling and storing cylinders per this SOP.

5. Personal Protection Equipment (PPE)

6. Procedure

Ensure you review the hazards associated with cylinders in Appendix 1 and 2.
See video for more information on handling compressed gas cylinders:
https://www.youtube.com/watch?v=uOvwDbNDdWA

Moving Cylinders:

1) Remove the regulator and make sure the valve protection cap is in place or that the smart-top valve is closed before moving a cylinder. Never move a cylinder with the regulator attached. See Figure 1 for valve protection cap image (below).

Figure 1

2) Do not lift a cylinder by the valve caps. Never sling with ropes or chains or lift with electromagnets.
3) Elevators must be used in all cases to transport cylinders.
4) Move cylinders with appropriate trolleys/carts (see Figure 2 below). Use proper lifting cradles. Cylinders can be rolled for short distances on their base in order to mount them on the cart.
5) Move cylinders individually onto the cart (in the upright position). Avoid striking other objects. Place the cylinder on the cart in an upright position. The cylinder must now be tightly secured with straps or chains (Figure 2 below). Do not ever transport cylinders that have not been strapped.
6) Lecture size or small compressed gas cylinders less than 3 inches in diameters and less than 20lbs can be hand carried.
7) While holding the cylinder, tilt the cylinder so that the rear wheels of the cart are touching the floor. It is now secure to transport the cylinder (Figure 3 below).
8) Cylinder MUST BE SECURED WITH STRAPPING once in position at the storage or point of use area (Figure 4 below).

Figure 2

Figure 3

Figure 4

Storing Cylinders

1) Cylinders must be stored in dry, ventilated areas.
2) Must be stored upright and capped when not in use (to protect valve from damage). Keep valves closed. Use the valve to shut off gas flow, not the regulator.

3) Cylinders must be labelled.
4) Cylinders should usually be strapped securely to an immovable object.
5) Must be kept away from fire, sparks and electricity, including intense sources of heat (ex. radiators, welding, and Bunsen flames). Ambient temperature should not exceed 52°C.
6) Compressed gasses that may react with one another either need to be stored in separate fire compartments or they need to be separated by specific distances.
7) Do not lay acetylene cylinders on their sides. If an acetylene tank has accidentally been left on its side, set it upright for at least 1 hour before it is used.
8) Do not try to refill a cylinder or mix gases in a cylinder.
9) Call the supplier to remove leaky cylinders immediately. Disposal of gas cylinders should be arranged with the gas supplier for empty or otherwise unneeded cylinders. In the event that this is not possible, follow the UofT Hazardous Waste Disposal Procedures found at http://www.ehs.utoronto.ca.

Cylinder Use:

Before commencing connection to the regulator:

1) Ensure the gas cylinder contains the gas of interest and it is securely fastened.
2) Remove the valve protective cap. It may require some force to remove.
3) Ensure the appropriate gas regulator is available
4) The appropriate tubing (chemically resistance, proper sizing, pressure sustainable) must be available to connect to the outlet valve/port.

Connecting the regulator to the cylinder:

1) Please note that some gas nut tightens clockwise (helium, nitrogen, argon) and some have gash which denotes they tighten counterclockwise (hydrogen, methane, air).
2) Teflon tape can be placed along the threads of the nut (Figure 5).
3) Take the regulator in your hand and place the nut onto the nipple of the regulator, to ensure a tight seal. HAND TIGHTEN the nut as far as possible. The appropriate gas regulator is available.
4) Once the regulator is secured tightly by hand, use the palm of the hand to firmly tap the wrench to secure an even tighter seal. When a dull metal thud sound is heard, similar to a muffled bell, then the regulator is attached properly (Figure 6).

Figure 5 and 6

Connection from the regulator:

1) Insert an equipment specific outlet valve to one (or more) of the outlet ports. Securely tighten the connection and check for leaks.
2) The outlet port should have an outlet valve to control the gas flow to your system
3) Connections to the outlet valve can be quick-connect, hose bard and Swagelok (1/8", 1/4").
4) Set up the appropriate tubing to the valve that will be able to sustain the pressure and chemical interaction with the gas
5) Consult the gas supplier or the equipment manufacture
6) Connect the tubing from the equipment to the outlet valve

Operating the regulator:

1) Do not face the regulator when you turn the gas valve and regulator on
2) Two major types of regulators exist. Single stage and Dual Stage
    - Single stage is less accurate when reducing the source pressure down to the desired delivery pressure in one step
    - Dual stage is more accurate in its ability to deliver a constant pressure, even with a decrease in inlet pressure
3) Turn on the flow of gas by turning the valve on the top of the gas cylinder counterclockwise in the direction of the arrows labeled "Open".
4) When using SmartTops ™, the flow of gas is 'opened' when raising the red valve at the top of the cylinder. See Figure 8 on page 5.
5) The cylinder regulator has two pressure gauges. The gauge to the right will read the pressure remaining in the cylinder. This gauge will IMMEDIATELY become active. NOTE: In most cases the gas supplier only guarantees the purity of the gas in the cylinder so long cylinder pressure is above 500psi. See Figure 7 (below) for diagram.

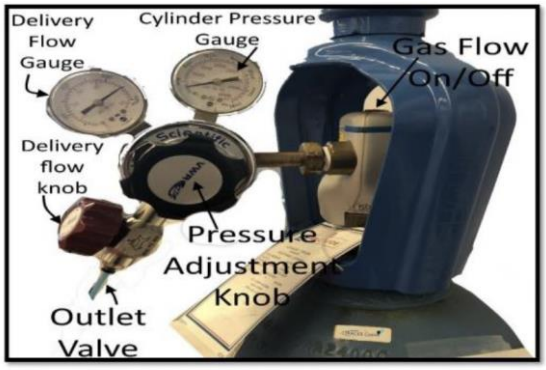


Figure 7

6) The gauge to the left is the delivery pressure. This gauge should be set to the required delivery pressure by turning the pressure adjustment knob.
7) Turn the delivery flow knob to "Open" and at this point the flow of gas should commence into the desired system.

8) In many cases the instrument/equipment must be operational to correctly 'fine tune' the delivery pressure.
9) If the gas is not needed it should be turned off by closing the valve on the top of the gas cylinder clockwise in the direction of the arrows labeled "Close".
10) When using SmartTops ™, the flow of gas is 'closed' when lowering/dropping the red valve at the top of the cylinder. See Figure 8 below.

Figure 8

Removing the regulator:

1) Cylinder should be replaced once the pressure inside the cylinder has dropped below 500psi
2) Ensure that the valve on the top of the gas cylinder is turned clockwise in the direction of the arrows labeled "Close"
3) At this point, allow the gas to purge into the system until it reads zero in BOTH gauges
4) Alternatively, close the delivery flow knob
5) Disconnect the tubing from the outlet valve
6) Slowly release the pressure by opening the delivery flow knob and release the pressure until it reads zero in BOTH gauges. CAREFUL. THIS SHOULD ONLY BE DONE WITH INERT GASES.
7) Disconnect the tubing from the outlet valve
8) Place the wrench onto the nut of the regulator, where it meets the cylinder. Firmly work the wrench in the opposite direction that it was secured.
9) Once it is loosened with the wrench, it is preferable to loosen the regulator by hand
10) Remove the regulator and store for future reuse.

Regulators should be connection leak tested on a regular basis, and creep (internal leak) tested at least annually. The frequency of testing depends on factors such as the toxicity of the gas, the corrosivity of the gas, and the use of the gas. More toxic, more corrosive and use of the gas in a critical system increase the frequency of tests. For low hazard situations, it is recommended by manufacturers that external leak testing be conducted monthly, and creep testing annually. Environmental conditions can dramatically affect the life of a regulator; of particular note is use outside or in salt spray (ocean) conditions.

Appendix 1: Compressed Gas Hazards

Figure 9 (Compressed Gas WHMIS Symbol 2015)

All compressed gases are under pressure and a great deal of potential energy is contained within the walls of each cylinder. This danger stores a potential rocket or bomb if the pressure is released through rupture of the valve or container failure.

Fire and Explosion Hazards

Flammable Gas

Fire and explosion may occur when gas concentration is within the flammable or explosive range in the presence of an ignition source or when the auto-ignition temperature is reached. MUST BE KEPT AWAY FROM Oxidizing Gases.
Examples: Acetylene, Hydrogen, Methane

Oxidizing Gas

Gas can react rapidly and violently with combustible materials and result in fire and explosion when mixed with oxygen at or above atmospheric concentrations. MUST BE KEPT AWAY FROM Flammable Gases. Examples: Oxygen, Nitrous Oxide, Xenon

Reactive Gas

When exposed to slight temperature or pressure increases, or mechanical shock, these can readily undergo certain types of chemical reactions such as polymerization or decomposition leading to fire or explosion. Examples: Vinyl Chloride, 1,3 Butadiene, Acetylene

Health Hazards

Inert Gas

The largest group of gases. They will displace air thus reducing oxygen levels and can cause loss of consciousness or even death. Examples: Nitrogen, Helium, Argon

Toxic Gas These gases can cause various health problems (including death) upon inhalation, eye, or skin contact. Examples: Hydrogen Sulphide, Suphur Dioxide, Silane

Corrosive Gas

Typically, the gas attacks and corrodes metals and in turn can destroy and burn body tissues on contact. Examples: Hydrogen Chloride, Ammonia

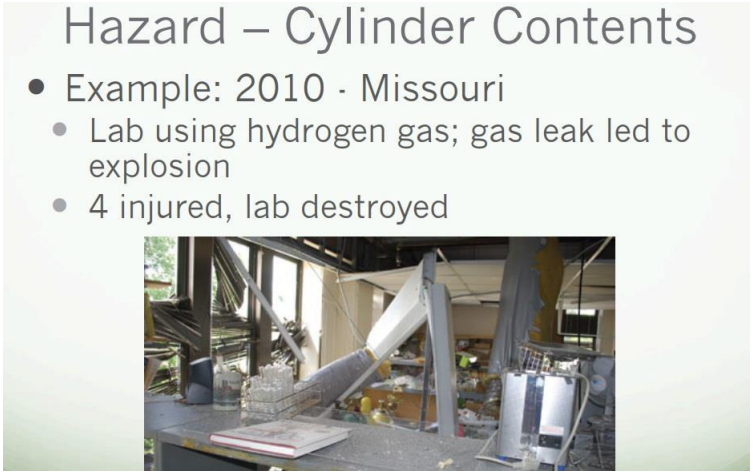
Poisonous (e.g. chlorine, fluorine), corrosive or dangerously reactive compressed gas The Principal investigator or manager of a lab that has the above compressed gasses must contact EHS to conduct a further assessment to ensure all procedures outlined in Section 5.6 Compressed Gas Cylinders of the Ontario Fire Code 213/07 and industry best practices are followed.

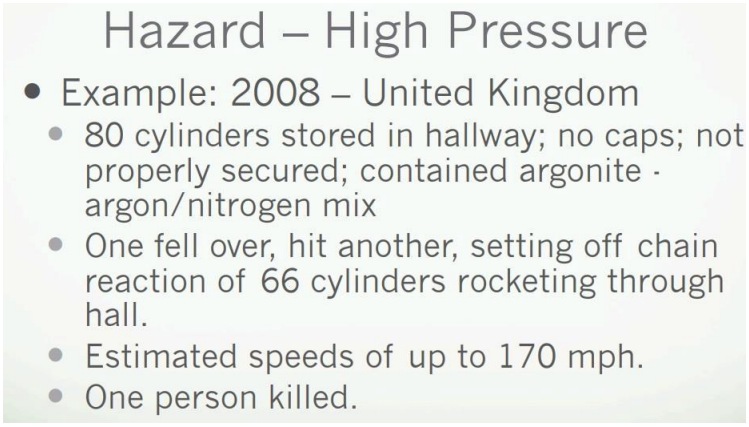
Compressed Gas Groupings

- Non-liquefied gases are also known as compressed, pressurized, or permanent gases. These gases do not become liquid when they are compressed at normal temperatures, even at very high pressures. Common examples of these are oxygen, nitrogen, helium, and argon.
- Liquefied gases are gases which can become liquids at normal temperatures when they are inside cylinders under pressure. They exist inside the cylinder in a liquid-vapour balance or equilibrium. Initially the cylinder is almost full of liquid, and gas fills the space above the liquid. As gas is removed from the cylinder, enough liquid evaporates to replace it, keeping the pressure in the cylinder constant. Anhydrous ammonia, chlorine, propane, nitrous oxide and carbon dioxide are examples of liquefied gases.
- Dissolved gases as gases dissolved in an inert material. Acetylene is the only common dissolved gas. Acetylene is chemically very unstable. Even at atmospheric pressure, acetylene gas can explode. Nevertheless, acetylene is routinely stored and used safely in cylinders at high pressures (up to 250 psig at 21°C). This is possible because acetylene cylinders are fully packed with an inert agamassan. The filler is saturated with acetone or other suitable solvent. When acetylene gas is added to the cylinder, the gas dissolves in the acetone. Acetylene in solution is stable.

Appendix 2

Cylinder Safety and the Importance of It





Reference Documents

- Ontario Fire Code O. Reg. 213/07, s.5.6
- How to Work Safely with Fact Sheets | Canadian Centre for Occupational Health and Safety
- Regulator Maintenance | Air Liquide
- Transporting Chemicals Within Buildings | The University of Toronto's The Office of Environmental Health and Safety
- Compressed Gas Use Program | The University of Michigan's Environmental Health and Safety Department
- CGA P-1, Safe Handling of Compressed Gases in Containers
- Compressed Gas Cylinder Use and Safety SOP | The University of Toronto's TRACES Centre
- Gas Cylinder Safety | Massachusetts Institute of Technology's Department of Materials Science and Engineering