Compressed Gases

A **Physical Hazard** arises when the use of a compressed gas is potentially dangerous due to, for example: the possibility of an explosion, fire or violent reaction. Examples of physical hazards of compressed gas cylinders include:

- Flammable gases
- Non- Flammable gases
- Oxidizing gases
- Pyrophoric gases
- Decompression of cylinders

Often those materials will also present a **Health Hazard**, due to their toxicity. Health Hazards of compressed gases include:

- Corrosive gases
- Cryogenic liquids
- Toxic gases
- Irritant gases
- Asphyxiation

**Flammable gases**

A flammable gas is a gas that can ignite readily and burn rapidly or explosively.

Flammable gases can be extremely hazardous in the workplace; for example: If the percentage of flammable material in the air is between the minimum and maximum limits, the presence of a flame or a source of ignition is likely to lead to rapid combustion or explosion. If there is inadequate ventilation, flammable gases can travel considerable distances to a source of ignition and flash back to the source of the gas.

- Common flammable gases are: Acetylene, Allene, Carbon Monoxide, Deuterium, Hydrogen, Methane and Propane
- Use in a fume hood or well ventilated area to prevent build up of flammable gases
- Never exceed the pressure limit indicated by the warning red line of an acetylene pressure gauge.
• Ensure outlet line of the cylinder is protected with a flash arrestor.
• Do not use a cylinder that has been stored in a non-upright position until it has remained in an upright position for at least 30 minutes.
• Observe separation distances, locate fire extinguisher and call 911 immediately in case of a fire.
• Conditions to avoid:

Avoid Ignition Sources

Do not use flammable gases inside Biosafety Cabinets (BSC). If flammable vapors or gases are allowed to recirculate and/or build up in a cabinet, a fire or explosion hazard is created.

Keep flammable gases away from electrical sources of ignition like electrical outlets.

Non - Flammable gases

This division includes compressed, liquefied, cryogenic, compressed gases in solution, asphyxiant and oxidizing gases.

A non-flammable, non-poisonous compressed gas refers to any material (or mixture) which exerts in the packaging an absolute pressure of 280 kPa (40.6 psia) or greater at 68°F (20°C), and does not meet the definition of a flammable gas.

• Common non-flammable gases are: Air, Ammonia*, Carbon Dioxide, Freons, Helium and Nitrogen.

*Although the United Stated Department of Transportation (US DOT) classifies Ammonia as a non- flammable gas, it is important to emphasize that Ammonia IS
flammable at concentrations of 15-28% and it also presents a corrosive and toxic hazard.

**Asphyxiation hazard:** In confined or poorly ventilated spaces, non-flammable gases can displace oxygen and cause asphyxiation or death.

**Oxidizing gases**

Oxidizing gases may promote combustion of materials, which will not normally burn in air. Oxidizer-promoted combustion is frequently more vigorous and violent than combustion in air.

- Common oxidizing gases are: Chlorine*, Fluorine*, Nitrogen Dioxide*, Nitric Oxide*, Oxygen and Ozone.
- Remember to keep oxidizing materials away from flammable gasses.

*Indicates a Toxic gas (NFPA health rating of 3 or 4)

**Pyrophoric gas**

A Pyrophoric gas is a flammable gas with an auto-ignition temperature in air at or below 1300° F (704° C).

- These gases may spontaneously combust in air.
- Common pyrophoric gases are: Silane, Disilane, Diborane (Borane)* and Phosphine*

*Toxic gas (NFPA health rating of 3 or 4).

**High-pressure hazard (Decompression)**

In compressed gases, decompression is a rapid release of pressure through a small opening like that of a valve stem.

- A sudden release of the gas can cause a cylinder to become a missile-like projectile reaching velocities close to 66mph, with enough force to penetrate concrete walls!
- To avoid this hazard, it is crucial that compressed gas cylinders are properly secured at all times (when in storage, use or transport).

**Corrosives**

Corrosive gases can cause visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact

- This category of gases include: Ammonia, Boron Trichloride, Chlorine, Hydrogen Chloride, Hydrogen Sulfide and Sulfur dioxide.
- Store for the shortest possible periods before use, preferably less than 6 months.
- Storage areas should be dry as possible.
- Do not store near instruments, chemicals or devices sensitive to corrosive atmospheres.
- Flush corrosive gas systems with inert gas after each use.

**Personal Protective Equipment (PPE)**

Corrosive gases can pose a serious immediate risk to skin, tissues, eyes and other parts of the body. To avoid skin and eye contact wear chemically resistant gloves, lab coats, face shield and splash goggles.

Emergency eyewashes must be available in the immediate vicinity (~20 feet) of the corrosive gas. In the event of skin contact with a corrosive gas, flush area with water for at least 15 minutes and seek medical attention.

If a corrosive gas cylinder shows signs of corrosion like the pictures below, call your gas supplier for a check (of the integrity of the cylinder) or replacement of the cylinder.

**Cryogenic fluids**

A cryogen is an extremely cold element or compound with a boiling point lower than -130°F (-90°C) at an absolute pressure of 101.33 kPa (14.7psia). That means that, at room temperature, and under normal conditions, cryogens will rapidly begin to boil and convert from a liquid to a gas.

- These gases are colorless, odorless, and tasteless.
- Common cryogenic fluids are liquid Nitrogen, Oxygen, Hydrogen, Helium and Neon.

**Asphyxiation hazard**

Cryogens will convert from a liquid to a gas at room temperature. In confined or poorly ventilated areas, the expanding gas will displace oxygen and can cause rapid asphyxiation or death (oxygen deficient conditions).
Personal Protective Equipment (PPE)

- Contact of a cryogen or a cold gas with the skin or eyes may cause serious freezing (frostbite) injury and cause embrittlement of many common materials, which may crack or fracture under stress.

- Use in a well-ventilated area. Some liquids and solids will condense and displace oxygen from the air creating an oxygen deficient environment. Liquefied gases expand to hundreds of times their liquid volumes and can asphyxiate people in low lying or confined areas.

- Wear appropriate PPE including insulated gloves and eye protection (splash goggles and face shield, lab coat and closed shoes) during ANY transfer of a cryogenic liquid.

- Transfer operations involving open cryogenic containers such as dewars must be conducted slowly to minimize boiling and splashing of the cryogenic liquid. NEVER leave a container unattended when filling!

- In the event of skin contact with a cryogenic liquid, do not rub skin, place the affected part of the body in a warm water bath (not to exceed 105°F (40°C).

- When using cryogens indoors, make sure the room is well ventilated and you have the cryogen stored in proper containment systems.

Poison (Toxic) Gases

Poisonous gases are a serious potential hazard to personnel and therefore require special storage and handling procedures. Poison gases are gases with a NFPA health hazard rating of 3 or 4 (4 = Deadly, 3 = Extreme danger). They are toxic by inhalation and have an LC50 (lethal concentration 50%) value below 5000 ml/m3 (5000 ppm).

- Common poison gases are Ammonia, Arsine, Carbon Monoxide (also a flammable gas), Diborane, Methyl Bromide, Nitric Oxide, Nitrogen Dioxide, Phosgene and Phosphine.

- Before using highly toxic or poison gas, the user must read the information on the container label and the MSDS of the material and be familiar with the hazards associated with the material.

- Always work with toxic gases in a well-ventilated area such as inside a chemical fume hood or gas cabinet.

- If a leak is detected, evacuate the area immediately, and contact Public Safety at 8-1-911. Do not attempt to move a leaking cylinder of toxic gas.

- Leak test all toxic gas cylinders prior to acceptance.

- Storage guidelines for poison gases:
- Use small lecture bottle size cylinders whenever possible and store according to the following guidelines.

<table>
<thead>
<tr>
<th>Gas cylinder size/type</th>
<th>Control procedures</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small lecture bottle size cylinders (fit inside hood)</td>
<td>Use and store cylinder inside a <strong>fume hood</strong></td>
<td></td>
</tr>
<tr>
<td>Large size cylinders</td>
<td>Use and store in ventilated cabinets with air monitoring and alarm system</td>
<td></td>
</tr>
</tbody>
</table>

**DOT Labeling**

**Shipping Labels**

The main agency regulating transportation of compressed gases in the United States is the US Department of Transportation (DOT).

- The DOT requires that hazardous materials that meet the definition of a compressed gas comply with labeling requirements
- Every compressed gas, when shipped, must be clearly and durably marked and labeled in accordance to the applicable regulations
- DOT labels marked by the shipper (usually the manufacturer) include the following information:
*UN number* - United Nations (UN) Numbers are four-digit numbers used world-wide in international commerce and transportation to identify hazardous chemicals or classes of hazardous materials. These numbers generally range between 0000 and 3500 and are ideally preceded by the letters "UN" (for example, "UN1005") to avoid confusion with other number codes.

Do NOT rely on cylinder color to identify gas within; always refer to the product label. If the label is missing or not legible contact the supplier.

Cylinder Specification Markings

- Cylinder markings are usually on the shoulder of the cylinder or into the valve guard ring welded to the cylinder.
- Under the DOT, cylinders must be permanently marked to indicate:

![Cylinder specification markings diagram]

- DOT specification (cylinder material)
- Tank service pressure in psi
- Serial number
- Manufacturer’s symbol
- Original tester symbol
- Means it can be filled to 10% above its pressure
- DOT 3AA - 2265
- AM - 99694
- MC
- 3 85
Cylinder Valves

A Cylinder valve or inlet fitting connects to the cylinder to allow gas to be withdrawn. The Compressed Gas Association (CGA) prescribes specific inlet fittings for each gas and mixture. These fittings are designed so that regulators that are incompatible will not be interchanged.

- Threads on fittings maybe right or left handed
- Right handed threads may be used for non-flammable gases.
- Left handed threads are used for flammable gases like Acetylene or Hydrogen.

Never force an inlet fitting onto a valve or use an adaptor!

Cylinder Valves

Pressure Relief Device (PRD)

Pressure relief devices are mechanisms on a cylinder valve that relieve gas pressure when conditions (temperature or otherwise) change inside the cylinder with the potential of causing rupture of the vessel.
A PRD allows gas to escape if the pressure inside the cylinder increases as a result of an adverse condition, e.g. excessive heat.

- There are different types of Pressure relief devices.
- Poison gas cylinders do not have PRD. Without a PRD there is no provision for controlled release and are therefore more likely to explode if exposed to fire.

Regulators

Regulators are used to safely reduce the gas pressure supplied by a compressed gas cylinder to a precise workable level.

The regulator body can be made from aluminum, brass, PVC (Polyvinyl Chloride) or stainless steel. The selection of the appropriate material will depend on the gas in use. Consult the compatibility table of your gas supplier's equipment manual.
Before the first use of the cylinder

- Ensure that the cylinder is equipped with the correct regulator and ensure that oil or grease are not used on the regulator under any circumstances. Grease and oil on the regulator can serve as fuel and cause a fire/explosion if connected to an oxidizing gas like oxygen.

Storage

Securing Cylinders

Gas cylinders must be secured at all times to prevent tipping. Secure cylinder firmly using two sets of chains each one-third from the ends of the cylinder.

Only store the quantity of gases you will need for one week.

Control cylinder inventory – return empty and unneeded cylinders in a timely manner.

If cylinders are not in use (regulators not connected) they may be group chained.

If in use, (cylinder connected to a regulator) compressed gas cylinders must be individually secured to a stable surface like a wall or laboratory bench.
Safety Caps

Safety caps are used to protect the cylinder valves and should remain on at all times, except when in use and connected to dispensing equipment. Leave the safety cap in place until you use the cylinder.

Careful when unscrewing cap clip!

Storage Positioning

Compressed gas cylinders must be secured in the upright position. If the cylinder is less than 1.5 Liters it may be secured horizontally using an appropriate rack as shown below.

Storage

Ventilation

All gas cylinders should be stored in a ventilated area. All gasses may act as asphyxiant by displacing the natural oxygen in the air, ventilation acts as a precaution against this potential hazard.

Storage Temperature

Cylinders should not be stored or exposed to temperatures above 120º F (51.7 ºC) -- especially those that do not have a pressure relief device (PRD), such as cylinders containing poison gases.
**Storage Separation**

In storage, oxidizing gases such as Oxygen, Nitrogen Dioxide and Nitric Oxide, must be separated from flammable gases or combustible materials (oil or grease). The minimum distance of separation is 20ft, unless there is a non-combustible barrier, like a concrete wall, between the cylinders.

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**Shelf lives**

- Some gases have relatively short shelf lives:
  - Some corrosive gases should not be stored longer than 6-8 months. For more information about shelf lives of specific gases consult your gas supplier.

**Monthly Charge**

- If a cylinder is no longer utilized, return it to the gas supplier to avoid unnecessary monthly charges.

**Transportation & Handling**

- Cylinders that contain compressed gases should not be subjected to rough handling or abuse.

- When moving a cylinder remember to:
  - Remove regulator and put safety cap before transport.
  - Cylinders must NOT be slid or rolled.
  - Secure cylinders to cart.
Handling of Compressed Gas Cylinders

1. How to connect a cylinder regulator:

- Unscrew safety cap.
- Remove safety cap.
- Inspect cylinder valve outlet for contamination.
- Momentarily open and close ("crack") cylinder valve to clear any contamination that may be present. Do not vent the valve if handling Toxic or Poison gasses. Avoid doing this practice with Hydrogen, it may explode.
- Inspect regulator connection for contamination. Do not use regulator if oil, grease or damaged parts are detected on the regulator inlet or the regulator valve.
- Position regulator.
- Attach regulator to cylinder valve.
- Use wrench to securely tighten regulator. Secure regulator tight enough not to leak.
No Teflon Tape on Connection - Bits of Teflon tape can get blown into the regulator causing a leak, value malfunction or erroneous reading.

Ensure regulator pressure adjusting screw is closed.

Connect hose.

Open the cylinder valve slowly. Never stand in front or behind a regulator when opening a cylinder valve. Always stand so that the cylinder is between you and the regulator.

Open cylinder valve slowly until pressure gauge is fully pressurized and open cylinder valve completely. Note: Do not open acetylene valves more than 1.5 turns and preferably, no more than 0.75 turns.

Open the regulator's pressure adjusting screw to the desired pressure.

Handling of Compressed Gas Cylinders

2. How to connect a liquid withdrawal hose to a pressurized liquid dewar (liquid nitrogen, oxygen withdrawal):

For liquid withdrawal, look for the valve labeled LIQUID.

Inspect cylinder valve and hose outlet for contamination. Do

Connect liquid withdrawal hose.
NOT vent the valve when withdrawing liquid.

Use wrench to tighten liquid withdrawal hose. NO TEFALON TAPE!

Assure liquid withdrawal hose has a phase separator and that this part is secured to the hose before putting it in the dewar.

**Notes:**

- No regulator is used to withdraw liquid nitrogen. The liquid withdrawal hose is connected directly to the cylinder valve.

- Use a liquid withdrawal hose with a phase separator.

3. **How to withdraw nitrogen gas from pressurized liquid dewars:**

Pressurized liquid dewar containing liquid nitrogen.

For gas withdrawal, look for the valve labeled GAS USE. Inspect cylinder valve and regulator valve for contamination.

Inspect regulator connections for contaminations, make sure connection is appropriate for the gas in use.
Momentarily open and close "crack" cylinder valve to clear any contamination that may be present.

Attach regulator to cylinder valve.

Tighten regulator connection with wrench.

Connect hose to regulator outlet.

NO TEFOLON! All cylinder connections are designed to connect without the use of Teflon tape.

Assure pressure adjusting screw is CLOSED and the delivery pressure reads zero.

Open cylinder valve slowly until cylinder pressure gauge is fully pressurized and finish opening valve. Never stand in front or behind a regulator when opening a cylinder valve. Always stand so that the cylinder is between you and the regulator.

Open the regulator pressure adjusting screw to the desired pressure.
Notes:

- Do not use towels or any other materials to clear out the cylinder valve; opening/closing the cylinder valve quickly should suffice.
- Do not use Teflon.
- Standing behind the cylinder valve is the safest location when connecting/disconnecting a pressure regulator.
- Regularly check hose for signs of damage or cracking.
- When the cylinder is not in use, turn off the cylinder valve.

Transportation & Handling

Use

Personal Protective Equipment (PPE)

- Wear protective equipment appropriate for the potential hazard of the material you are working with.
  - Eye protection: safety glasses or face shield and splash goggles.
  - Protective clothing: cryogenic gloves, lab coat and closed toe shoes.
Opening / Closing Cylinder Valve

- The cylinder should be placed so that the valve handle at the top is easily accessible at all times.
- Open the valve slowly- never leave a valve part open, either open all the way or close it all the way.
- The cylinder valve should never be left open when equipment is not in use- air and moisture can diffuse through the valves causing contamination and even corrosion within the cylinder.

Leak Check

- Leak detection procedures should be implemented prior to use of any system using compressed gases. This can be accomplished by doing the following:
  - For flammable gases, a soapy water solution or a 50% glycerin-water solution should be used. "Snoop" available from University Stores or your gas supplier, may be used for this purpose; Bubbles will indicate a leak.
  - For systems where toxic or corrosive gases will be used, first conduct a leak check of the system with an inert gas (i.e. argon, nitrogen) before introducing the toxic gas in the system.

Transportation & Handling

Gas Leaks

PI and lab personnel must be familiar with hazardous gases in their lab. Emergency response for gas leaks will vary according to the chemical hazards involved. Lab personnel should never attempt to repair defective or damaged cylinders or cylinder valves.

- Non-emergency leaks- if the leak is not significant and cannot be remedied by tightening the valve, consider moving the cylinder to an isolated, well-ventilated area (fume hood, if possible). Keep oxidizing materials away from flammables and combustibles.
Never attempt to repair a leak at the valve threads or safety device. Notify EHS and the gas supplier.

- Emergency leaks-if the leak is significant or the gas involved is toxic or flammable (NFPA Rating 3 or 4), pull fire alarm, evacuate the area and call 8-8911.

**Cylinder Disposal**

A cylinder is considered empty when the pressure in the cylinder is approximately 15-30 psi. To dispose of empty cylinders or viable cylinders that are no longer utilized, the following steps should be taken:

1. Remove regulator from cylinder and put the safety cap on.
2. Move cylinder to storage area for empty cylinders.
3. Fill out **Cylinder Return Form** to return to the gas supplier.
   - Refillable cylinders should be directly returned to the respective supplier.
   - Submit a pickup request to dispose of cylinders only if disposal through the supplier is not possible.

**Keep in mind:**
Never empty a cylinder completely. This will prevent a flash back into the cylinder and contamination into the cylinder and a possible explosive mixture.