MISSISSIPPI STATE UNIVERSITY™
ENVIRONMENTAL HEALTH AND SAFETY

Compressed Gas & Cryogenics

REFERENCE GUIDE

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All compressed gasses are hazardous and can create very dangerous working environments if not properly stored, handled, and utilized. The quantity of compressed gases should be kept to an absolute minimum and are subject to IFC maximum allowable quantities (MAQ's) for each fire zone.

Cryogenic liquids, or cryogens, are gases at ambient temperatures and pressures but liquids at low temperatures. Cryogens have a temperature roughly below –150°C and very low boiling points. When vented from compressed gas cylinders, cryogens release very cold vapors that condense into highly visible fog. Very small quantities of cryogens 'boil off' into very large volumes of gas.

The following key aspects will be addressed:

- **Types of Compressed Gas**
- **Storage & Transportation**
- **Operating Guidance**
- **Cryogenics**

Types of Compressed Gas

There are three major types of compressed gases: liquefied, non-liquefied, and dissolved.

1. **Liquefied gases** are gases that can become liquids at normal temperatures when under pressure in a cylinder. The gases exist in a liquid-gas equilibrium in the cylinder. Liquefied gas cylinders must be stored in an upright position so that the pressure relief valve is in direct contact with the vapor/gas space of the container. Examples of liquefied gases include anhydrous ammonia, chlorine, propane, and carbon dioxide.
2. **Non-liquefied gases** are gases that do not become liquid at normal temperatures, regardless of the pressure. Common non-liquefied gases are oxygen, nitrogen, helium, and argon.
3. **Dissolved gases** are gases that are absorbed into a solvent to increase the stability of the gas. The only common dissolved gas is acetylene, which is dissolved in acetone. Dissolved cylinders must be stored in an upright position so that the pressure relief valve is in direct contact with the vapor/gas space of the container. The discharge pressure must be 15psig or less.

Storage & Transportation

- **Compressed gas tanks must be strapped to a stationary object at all times when not in transport.**
  - Compressed gas tanks should be secured to a fixed structure (wall or lab bench/ cabinet) by a chain or strap capable of holding the weight of the tank. The chain or strap must be located approximately ¾ the way up the tank and tight enough that rocking of the tank is not possible. Two chains or straps, located at the top and bottom of the tank, may be used as long as they prevent rocking of the tank.
  - Only items designed and manufactured to store compressed gas tanks or I-hooks drilled directly into a wall stud or properly anchored can be used. C-clamps attached to bench tops are not appropriate for compressed gas storage.
  - A maximum of 3 compressed gases can be chained or strapped together. Tanks must be positioned with at least one side touching a stationary object and the other sides touching another tank or secured by a chain or strap. If multiple tanks are chained or strapped together, the chain or strap must be attached to I-hooks properly secured

to the wall or other fixed structure or to a compressed gas wall-mounted bracket.
  - If a compressed gas tank storage rack is purchased, the number of tanks held within the rack cannot exceed the manufacturers' storage maximum.
  - Items such as rope and bungee cords are not appropriate securing materials.
  - These requirements apply to compressed gas storage and filling locations.
- **The protective cap must be in place when the tank is not in use.**
  - The protective cap or device must be tightly secured to the tank to protect the valve stem when the tank is not in use or in storage. A tank is considered to be in use if it is connected via an appropriate regulator to a piece of equipment or currently connected for use.
- **Transportation of compressed gases shall utilize a hand cart/ truck or other mobile device designed for the secure movement of compressed gas tanks or cylinders.**
  - Carts and trucks approved for moving compressed gas cylinders are designed so that the cylinder/tank are secured against dropping and striking against one another or other surfaces.
  - The chains or straps on the hand carts or trucks must be utilized and should be tight against the body of the tank.
  - Tanks should not be drug, carried, or transported on devices not designed for such use.
- **Compressed gas cylinders must be appropriately labeled.**
  - The shipping label on the shoulder of the tank must indicate the shipping name and identification number. Pure products will also have the grade assigned to the gas on the shoulder.
  - The applicable DOT hazardous material placard(s) must be present on the label at all times.
- **Additional information of proper storage locations and positioning of tanks.**
  - Compressed gas tanks cannot be stored in egress pathways.
  - Compressed gas tanks should be segregated from incompatible materials, extreme temperatures (>125^{o}F or below sub-ambient), falling objects, ignition sources, or chemicals which could damage the integrity of the tank.
  - Tanks should be stored and used in well-ventilated locations.
  - If outdoor storage is utilized, tanks must be protected from direct contact with soil or unimproved surfaces. The surface should be graded to prevent the accumulation of water.
  - All tanks must be stored in an upright position, unless recommended by manufacturer.
  - Full cylinders must be stored separately from empty cylinders. Empty cylinders should be picked up by the distributor as soon as possible.
  - Cylinders should be used in the order in which they were received. Only the quantity of cylinders needed for current work should be kept. Unused cylinders and cylinders that have no indented future use must be returned to the vendor.

Operating Guidance

- The hazard associated with each gas should be known and understood by all users.
- The hazards associated with using compressed gases with the equipment being used should be known, understood by all users, and written procedures should be followed to mitigate those risks.
- Only the approved CGA regulator for each specific gas may be used. Regulators must be attached prior to opening the gas cylinder valve.
- Do not force cylinder valve connections that do not fit. Thread sealer, Teflon tape, etc. must not be used on valve fittings.
- Open the cylinder slowly after being connected to the process. Check for leaks via an appropriate bubbling solution or gas detector.
- 'Hard' piping made of materials such as copper or stainless steel should be used whenever possible. Cast iron pipe and fitting should never be used.
- Teflon tape should be used only on low pressure connections post regulator. All regulator connections need to be direct metal to metal (i.e. compression fittings).

- If flexible tubing must be used, the tubing must be compatible with the properties of the gas in use and the tubing should remain 'in sight' (not through walls or ceilings). Flexible tubing cannot be used with toxic gases.

Cryogenics

- There are four main hazards associated with cryogens.

1. Physical hazards such as contact burns and asphyxiation are prevalent when working with cryogens.

- Contact burns are similar to heat burns in which contact can locally freeze and tear or remove skin and damage eye tissue. Due to the nature of cryogens low viscous nature, they will easily penetrate woven and other porous clothing material much faster than water. Touching materials that are kept at these low temperatures can also cause contact burns. The following PPE should be worn while working with cryogens: full-face shield over safety glasses, loose-fitting thermal insulated (cryogenic) gloves, long sleeve shirt and/or laboratory coat, pants without cuffs, and full-coverage non-absorbent shoes. Cryogenic gloves are only intended for short-term contact, not immersion.
- Cryogens rapidly boil off at room temperature producing large quantities of gas relative to the liquid volume. The gas produces a fog cloud where the vapor is still cold, but expands far beyond the fog cloud. This large and rapid out-put of gas can easily cause asphyxiation of any personnel in the area, especially if the area is not well ventilated. Some gases will displace oxygen in the air. Cryogens should only be released in well-ventilated areas.

Liquefied Gas	Boiling Point Centigrade	Volume Expansion to Gas (L)
Helium-3	-269.9	757 to 1
Helium-4	-268.9	757 to 1
Hydrogen	-252.7	851 to 1
Neon	-245.9	1438 to 1
Nitrogen	-195.8	696 to 1
Argon	-185.7	847 to 1
Oxygen	-183.0	860 to 1
Methane	-161.4	578 to 1
Nitrous oxide	-89.5	666 to 1
Carbon dioxide	-78 5(b)	553 to 1

2. Some cryogens are flammable gases, such as hydrogen, methane, and acetylene, and the flammable concentration of the gas can easily be reached when boiling- off if proper ventilation is not used. Liquid oxygen quickly creates oxygen-rich environments that can cause organic materials to react explosively in some situations. Flammable cryogenic gases and liquid oxygen must be used in intrinsically safe rooms with no flammable or combustible materials. Contact EH&S for assistance in working with cryogenic oxygen and/or flammable gases.

3. Cryogens are under high pressure like all other compressed gases. It is vital that the pressure relief valve is working properly to allow venting of off-gases produced during storage. On average, a 160 liter tank will vent ~2 liters of liquid a day, depending on storage conditions. Excessive venting or ice-build up on vessel wall may indicate an issue with the pressure relief valve. In this instance, the area should be evacuated, marked as hazardous, and the distributor should be contacted to remove the tank.

4. Due to the low temperatures, many materials cannot be used with cryogens. Rubber, plastic, and carbon steel become brittle and can break with minimal stress applied after being exposed to cryogens. Only use materials that are certified by the manufacturer for use with cryogenic materials. All cryogenic material containers must be properly ventilated.