

## Compressed and Liquified Gases

### NFPA 55:3.3.49.1 Compressed Gas definition:

A material, or mixture of materials, that (1) is a gas at 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) and (2) has a boiling point of 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) and that is liquefied, nonliquefied, or in solution, except those gases that have no other health or physical hazard properties are not considered to be compressed gases until the pressure in the packaging exceeds an absolute pressure of 40.6 psi (280 kPa) at 68°F (20°C).

Compressed gases may present both physical and health hazards. Gases may be flammable, reactive, corrosive or toxic and these properties must be considered when developing experimental procedures and designing apparatus. In addition, compressed gases, when not handled properly or not contained in properly designed vessels, can be extremely hazardous with a high potential for explosion. Although each approved gas cylinder is designed, constructed, and tested to safely contain its contents, the procedures listed below should be taken in handling and storing of compressed gases\*.

*\*Work with particularly hazardous gases with special procedures and in approved gas storage cabinets. Researchers must contact EH&S (644-7682 or 644-8916) before working with highly toxic (e.g. arsine, diborane, methyl bromide, nitric oxide, nitrogen dioxide, phosgene, phosphine), extremely flammable, reactive or pyrophoric gases (e.g. Silane, phosphine). Gases with these properties require adherence to special building and fire codes.*

### **General Procedures for Proper Handling of Gas Cylinders**

- Compressed gases must be handled by trained personnel only
- Personnel must use appropriate PPE, including eye protection
- Regulators must be used to safely reduce pressure using an appropriate pressure regulator, and must include two gauges indicating cylinder pressure and outlet pressure – see Guidelines for Compressed Gas Systems and Regulators below
- Pressure gauges should not be used above 75% of its maximum face reading
- Any pressurized system (piping, manifold) that can be isolated or closed off must have its own pressure relief device and should vent to safe locations
- Cylinder contents must be clearly identified on the cylinder
- Cylinders must be marked for maximum pressure
- If source cylinder is outside lab unit, a regulator & gauge must be installed at point-of-use. Example is indicated in the photo to the right.
- Cylinders must have manual shutoff. Handles for shutoffs may not be removed or altered
- Cylinders and tanks must be protected from physical damage by means of protective caps, collars, or similar devices (capped when not in use)
- Compressed gases must be separated from each other by chemical compatibility and must be separated from materials or conditions that are not compatible with safe storage (by 20 ft distance or 5 ft. high 30-minute rated fire resistant barrier in accordance with NFPA 55 Section 7).

- Trucks, carts or hand trucks used for movement of cylinders must be designed for secure transport

### **Guidelines for Compressed Gas Systems and Regulators**

- Never use a compressed gas cylinder without a pressure reducing regulator or device to safely reduce pressure to the system. The regulator used MUST be appropriate for the specific compressed gas.
- Never use a gauge above 75% of its maximum face reading. A 3000psi system should use at least a 4000psi gauge. A system that has a 75 psi maximum pressure should use a gauge that can read to 100 psi.
- Regulators should be replaced immediately if the gauge does not return to the zero point when the pressure is removed
- Never use an adaptor between a cylinder and a pressure reducing regulator
- Valves should be accessible at all times, unless the valve cap is in place
- Teflon tape should not be used on regulators or connections
- All cylinders should have adequate pressure relief devices. They should be sufficient to discharge pressure at a rate which avoids internal pressure increases. Gases that are discharged must be vented to safe location.
- Piping and tubing that connects between a flammable gas cylinder and a laboratory device or apparatus must be leak tested using an inert gas prior to utilizing the system for delivery of the flammable gas. This may be accomplished by placing a small amount of soapy water on joints and connections to look for bubbles.
- If a leak of a flammable gas is suspected, turn off the gas and contact EH&S.
- Backflow check valves should be used when oxidizing gases and flammable gases are connected to a common piece of equipment
- Systems for compressed gases and cryogenics shall comply with the manufacturer's design and specifications
- Regulators, valves, piping, tubing, fittings and other apparatus must be of compatible material and design in accordance with ASME B31.3. Regulators and valves must be appropriate for the type of gas.

### **Procedures for Attaching a Pressure-Reducing Regulator**

- Turn the regulator's adjustment screw out counter-clockwise until it feels loose
- Stand behind the cylinder with the valve outlet facing away from you
- Watch the pressure gauge on the regulator from an angle, do not pressurize the gauge looking directly at the faceplate
- Open the valve on the regulator slowly until you hear the gas filling the space between the cylinder valve and the regulator
- When using nontoxic, non-flammable gases impurities can be purged from the system by shutting off the cylinder valve and gently cracking the CGA connection at the cylinder valve

(generally three pressurizations with venting will clean the interior of the connection and ensure a clean representation of the gas in the system)

- When you are ready to use the cylinder fully open the cylinder valve until you feel it stop. Then close it one quarter turn.

### **Gas Cylinder Storage Requirements**

- Cylinders must be secured from tipping over
- Cylinders must be stored in a cool, dry area away from ignition sources, electrical supply sources and heat. Compressed gases must be protected from heat, open flames, heat sources, and weather
- If not in use, compressed gases must be stored outside lab unit (except 0.5 Kg propane cylinder)
- Considered “in use” when connected via regulator to lab equipment, manifold or lab operation OR may be a single reserve cylinder (other reserve cylinders should be stored in approved location outside lab unit)
- Cylinders and tanks must be secured against unauthorized access
- Cylinder valve should be closed when not in use or when being stored full or empty.
- Valves should be accessible at all times even when cylinders are being stored full or empty.
- Cylinders should always be stored in the upright position
- Do not store cylinders with acids and/or bases.
- Do not store cylinders on the tops of shelves or cabinets.
- Keep flammable gases away from doorways and emergency exits.
- Do not gang together groups of more than 4 cylinders.
- Store oxidizing gases away from flammable gases. Oxygen cylinders should not be stored with cylinders that contain flammable gases. Oxygen cylinders should be separated from combustible materials 20 feet or by a fire barrier.

### **Maximum Storage at 21°C & 1 atm (see specifics for lecture bottles)**

- Flammable or Oxidizing gases – no more than 6 ft<sup>3</sup> for ≤ 500 ft<sup>2</sup> lab unit; contact EH&S for storage limitations in larger lab units (cylinder 53” tall by 8” diameter = 1.4 ft<sup>3</sup>)
- Liquified Flammable gases – no more than 1.2 ft<sup>3</sup> for ≤ 500 ft<sup>2</sup> lab unit; contact EH&S for storage limitations in larger lab units
- Toxic (NFPA Health Hazard 3 or 4) – no more than 0.3 ft<sup>3</sup> for ≤ 500 ft<sup>2</sup> lab unit; contact EH&S for storage limitations in larger lab units

### **Outdoor Storage**

- A weather protection structure is permitted to be used for sheltering outdoor storage of compressed gas cylinders
- Hazard identification signs shall be placed at all entrances to locations where compressed gases are stored

- Outdoor storage of flammable gases requires a minimum distance of 5 feet from structures for quantities of gases <math><4,225\text{ ft}^3</math>
- Storage and use of flammable gases shall not be located within 50 ft of air intakes
- The structure shall allow for natural ventilation to prevent accumulation of hazardous gases
- Ignition sources in area where flammable gases are stored should be controlled or eliminated if possible
- Signs should be posted in area communicating that smoking or open flames should not be permitted in area
- Static producing equipment in storage area shall be grounded

#### **Lecture Bottles**

- Must be stored in a continuously ventilated enclosure if gas is NFPA health hazard 3 or 4; gas is NFPA health hazard 2 with no physiological warning property; or gas is pyrophoric – contact EH&S for further requirements
- No more than 25 lecture bottles are permitted within a research lab in accordance with NFPA 45.
- Lecture bottles containing non-flammable gases are permitted to be stored horizontally

#### **Gas Cylinders of Toxic, Corrosive, or Pyrophoric Gases**

- See lecture bottles above
- Cylinders larger than lecture bottles that contain gases with NFPA health hazard 3 or 4; gas with NFPA health hazard 2 and no physiological warning properties; MUST be stored in a continuously ventilated gas cabinet. Cylinders containing pyrophoric gases must be stored within continuously ventilated and sprinklered gas cabinets.
- Health and fire protection requirements must be met for storage and use of toxic, corrosive or flammable gases in accordance with NFPA 55 Section 6.
- Cylinders of corrosive or unstable gases should be returned to the vendor by the expiration date

#### **Emergency Procedures for Gas Cylinders**

##### **If there are associated injuries, call emergency personnel at 911 or 644-1234**

It is extremely important to use caution when approaching someone injured or unconscious near a compressed gas cylinder system. If the system is leaking, there could be an oxygen deficient atmosphere around the injured person, which would make it dangerous for others to get close. Entering the oxygen deficient atmosphere could cause the rescuer to become unconscious as well.

- Turn off gas at regulator if it is safe to do so.
- Pull fire alarm and exit to a safe area
- Immediately evacuate the area of the spill or leak. Evacuate students and staff from labs adjacent to location of spill.
- Report the spill or leak to your supervisor immediately.
- Never re-enter the area until it has been determined "Safe" by a Safety Coordinator or your supervisor.

- Be sure others know there is a leak or fire
  - Use fire extinguisher to put out small fires
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#### Additional Information and Resources

- [Inert gas created O<sub>2</sub> deficient atmosphere](#)
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#### Additional Information and Resources

- [Gas Cylinder Safety Checklist](#)
- [Video - Regulator Installation](#)
- [Airgas](#)
- [Scotte Catalog](#)
- [Safety Equipment](#)
- [Gas cylinder size information](#)
- [Compressed Gas Association](#)
- [OSHA Compressed Gas Regulations](#)
- [Hydrogen Fuel Cell Codes & Standards](#)
- [Hydrogen safety](#)
- [Nitrogen](#)
- [Carbon monoxide](#)
- [Hydrogen chloride](#)
- [Fluorine](#)
- 1, 3-butadiene
  - [Link 1](#)
  - [Link 2](#)
- [Pressure vessel guidelines](#)
- NFPA 55 – Contact EH&S for information regarding these regulations
- [Don't Turn Cylinder into a Rocket](#)