DEPAUL UNIVERSITY

Compressed Gas Safety Manual

Environmental Health & Safety

April 2017

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APPENDICES

1.0 PURPOSE

The Compressed Gas Safety Manual was created to ensure the safe use of compressed gases and all associated equipment by DePaul University employees and students, and to ensure compliance with applicable OSHA and industry consensus standards.

2.0 SCOPE

This manual applies to all DePaul University employees (including student employees) and students who use, transport or regularly work in areas where compressed gases are present.

Air duster cans used for cleaning office electronics are exempt from this manual provided they are used according to the manufacturer's instructions and the user's exposure is no greater than what the typical consumer would experience. Small helium tanks used for events are also exempt provided they are used and disposed of according to manufacturer's instructions. Large helium tanks designed for commercial use are subject to this manual's requirements and pose an oxygen displacement hazard (see Section 4.2).

This manual does not cover requirements for respirator users. Please see the Respiratory Protection Program for information about using a respirator at DePaul.

3.0 RESPONSIBILITIES

- Facility Operations

  Facility Operations is responsible for ensuring that its employees who work with or around compressed gases receive proper training as defined in this manual before they are exposed to the hazards.

- Laboratory Personnel

  All laboratories that use and/or store compressed gases must ensure that all personnel (including students, if applicable) receive proper training as defined in this manual before they are exposed to the hazards.

- Environmental Health & Safety (EHS)

  EHS is responsible for reviewing this manual annually and updating it whenever new safety-related information becomes available.

- Other Departments

  Any other departments that use compressed gases covered by the scope of this manual are required to follow all requirements herein.

4.0 COMPRESSED GAS HAZARDS

Most compressed gases are stored in gas cylinders. For the purposes of this manual, tanks/other containers are included in the definition of gas cylinder (see Appendix A: Definitions). Cylinders present physical hazards due to the pressurized nature of their contents. They can become projectiles if stored or transported in a manner that damages their valve. They may explode if

heated. Cylinders may also present one or more specific hazards covered below depending on their contents. See Appendix A: Definitions for examples of gases that exhibit these specific hazards.

4.1 Flammability

Before using flammable gases, take note of ignition and heat sources such as open flames, sparks, static electricity, oxidizing agents and ungrounded or non-intrinsically safe equipment and maintain adequate distance from them.

Many flammable gases are heavier than air. If leaked into a poorly ventilated area, these gases can settle and collect in sewers, pits, trenches, basements and other low lying areas. The gas trail can spread far from the cylinder, make contact with an ignition source and produce a fire that can flash back all the way to the cylinder.

In the case of hydrogen gas, even the simple flow through tygon tubing can generate static electricity and cause a fire.

Pyrophoric gases are an especially dangerous type of flammable gas that will ignite upon exposure to air.

4.2 Oxygen Displacement

Oxygen displacing gases, if left to leak into enclosed space, may displace oxygen and create a risk of asphyxiation.

The inert gases are of primary concern for oxygen displacement. Nitrogen and carbon dioxide are commonly thought of and used as inert gases, but they are not truly inert. Although nitrogen and carbon dioxide are relatively nonhazardous otherwise, they also pose this hazard.

4.3 Oxidation and Corrosion

While slightly different, oxidizing and corrosive gases both have destructive effects on living tissue and metals, causing burns, degradation, etc. Oxidizing gases also cause other materials to burn more violently.

4.4 Compressed Air

Compressed air presents unique hazards. It must not be used for cleaning (of equipment, tools, etc.) unless it is reduced to less than 30 psi with effective chip guarding and proper use of PPE.

Employees and students are strictly prohibited from using compressed air to clean themselves or their clothing. Compressed air can enter the body wherever skin is not present (e.g., ear, nose, any small scratch or puncture) and cause severe swelling and pain. If air enters the bloodstream, it can travel to the small blood vessels of the brain, burst them and potentially cause death. A pressure strong enough to dust or clean is strong enough to breach the skin and penetrate the body. Even pressures as low as 5-10 psi can cause serious injury.

5.0 TRAINING REQUIREMENTS

Only employees and students who have received training and are knowledgeable about the general hazards of compressed gases, the specific hazards presented by the gases they work with or around, the proper accessory equipment, site specific standard operating procedures (SOPs) and emergency plans are permitted to handle or regularly work in any area containing compressed gases.

Refresher training is required for all that handle compressed gases whenever SOPs change and for all who regularly work in an area where a new gas is introduced.

6.0 RECEIVING INSPECTION

Before receiving gas from a vendor, be familiar with the chemical properties and specific hazards of all gases in the shipment. This can be accomplished by reviewing all applicable SDSs.

Do not rely on the color of the cylinder to identify the gas. Different vendors may use different colors for cylinders of the same gas.

When the vendor arrives:

- Verify the presence of labels, tags and shipping papers.
- Check for evidence of exposure to fire (e.g., charring or burning of paint, burning or scarfing of the metal, distortion of the cylinder, burning or melting of a valve).
- Be sure cylinders are not giving off odors, visible fumes or hissing sounds.
- Verify that the cylinder was last hydrostatic pressure tested within the past 5 years.
- Do not accept cylinders that are damaged in any way or do not comply with the above requirements.

Once the receiving inspection is complete, record the date received on a tag or reference log and ensure that all cylinders are marked as "FULL."

7.0 PROPER USE

7.1 General Practices

- Always wear PPE suitable for the specific hazards of the gas you are working with.
- Do not use any cylinder that cannot be identified positively.
- Do not introduce another product into a cylinder.
- Do not permit cylinders to become part of an electrical circuit.
- Do not strike an electric arc on a cylinder. Arc burns can weaken the metal.
- Do not discharge the contents from any cylinder directly towards any person.
- Do not install shut-off valves between pressure relief devices and the equipment they protect.
- Do not attempt to catch a falling cylinder. It is often a reflex to do so, but the risk of injury (e.g., contusions, fractures, broken bones, sprains, strains, spinal cord injuries) far outweighs the potential damage to equipment.
- Do not paint cylinders.

- Do not subject cylinders to artificially created low temperatures without approval from the vendor.

7.2 Valves and Pressure Regulators

Cylinders may only be attached to an instrument or system by means of a pressure regulator that will safely reduce the cylinder pressure to the pressure of the system.

Do:

- Use only regulators designed for the specific gas, marked for the maximum cylinder pressure and equipped with two gauges that show the cylinder and outlet pressure.
- Use a cylinder cap hook to loosen tight cylinder caps.
- Use check valves to prevent reverse flow into the cylinder.
- Ensure that the regulator's pressure control valve is relieved (i.e., closed) before attaching it to cylinders.
- Return cylinders with "stuck" valves to the vendor for repair.
- Open valves slowly and carefully after the cylinder has been connected to the system.
- Stand to the side of the valve outlet when opening the valve and attaching the regulator.
- Fully open valves during use. A fully open valve improves the internal seal and helps prevent packing leaks.
- Vent relief valves to a fume hood or ventilated gas cabinet when using flammable or toxic gases.
- Close valves and cap cylinders anytime an extended non-use period is expected.

Do Not:

- Do not use lubrication of any kind on regulators.
- Do not use adapters or exchange fittings between tanks and regulators.
- Do not apply excessive force to pry off caps, open valves or make valve connections.
- Do not use a hammer or wrench to open valves.
- Do not partially open a valve to remove dust or debris from the inlet.
- Do not attempt to open a corroded valve. It may be impossible to reseal or it may break and release the cylinder's contents.
- Do not use Teflon tape on Compressed Gas Association (CGA) fittings (straight thread) where the seal is made by metal-to-metal contact. Use of Teflon tape causes the threads to spread and weaken, increasing the likelihood of leaks. Small pieces of tape can also become lodged in the valve mechanism resulting in possible valve failure.

7.3 Hazard Specific Practices

- Use non-sparking tools when working with flammable gases.
- Only work with oxidizing gases with clean hands.
- Never use oil, grease, solvents, or other flammable material on oxidizing gas valves, regulators or piping, and do not permit these materials to come in contact with oxidizing gases.
- Regulators and tubing used with oxidizing gases must be regularly cleaned to remove all reducing agents or explosions may occur.

8.0 STORAGE

8.1 General Requirements

Store cylinders:

- In well-ventilated areas – NEVER in drawers, cupboards or cabinets that are not designed for gases.
- In an upright position – UNLESS specifically designed for horizontal storage.
- With enough room to access them as necessary and away from clutter.
- Away from direct sunlight, hot surfaces/heating equipment, damp areas, salt, corrosive chemicals, fumes, falling objects, etc.
- According to their compatibility.
    - Separate full and empty cylinders.
    - Gases in the same hazard class can be stored together. Inert gases are compatible with all other gases.
    - Non-compatible gases (i.e. flammable gases and oxidizing gases) must be stored at least 20 feet away from each other.
    - Flammable gases must be kept at least 20 feet away from all flammable, combustible or incompatible substances.
        - Exception: Storage areas that have a noncombustible wall at least 5 feet in height and with a fire resistance rating of at least 30 minutes may be used to segregate gases of different hazard classes in close proximity to each other.
- Secured with a chain or appropriate belt above the midpoint, but below the shoulder.
    - Lecture bottles may be secured by approved stands or wall brackets.
- Capped when not in use.
- If storing outdoors: Drainage, ventilation, overhead cover and adequate security measures are required to prevent unauthorized access.
- Away from stairways, egress routes and exits.
- For no longer than 1 year without being used.

8.2 Hazard Specific Requirements

Flammable Gases

- Appropriate fire extinguishers must be available wherever flammable gases are stored.
- Pyrophoric gas cylinders must be kept in approved continuously mechanically ventilated gas cabinets with a sprinkler.
- Post “NO OPEN FLAMES” signs on access doors to flammable gas storage areas.

Oxidizing and Corrosive Gases

- Store oxidizing and corrosive gases in areas constructed of noncombustible and corrosion resistant materials, respectively. Check SDSs for further information on proper storage.

9.0 TRANSPORT

Cylinders are heavy and awkward to move and improper handling can result in physical injuries as well as fires, explosions, chemical burns, poisoning, etc. Extreme caution must be used when transporting cylinders.

- Wear hard-toed shoes and PPE suitable for the specific hazards of the gas.
- Only use a hand truck specifically designed for moving cylinders unless they can be physically carried with ease.
- Do not lift a cylinder by its cap or with magnets.
- Make sure the cap is secured before moving the cylinder onto the hand truck. If the cap is damaged or loose, the cylinder may become a projectile.
- Once the cylinder is loaded onto the hand truck, secure it in place with the proper chains and/or straps.
- Always push, never pull, cylinder hand trucks.

10.0 DISPOSAL

A cylinder is considered empty when the pressure is approximately 30 psi. Cylinders should be returned to the vendor with at least this pressure to reduce the risk of foreign materials entering the empty vessel. Do not attempt to refill any cylinders yourself. Do not dispose in any way other than by returning to the vendor. If you are unable to return a gas to a vendor for any reason, contact EHS for assistance.

11.0 LEAKS AND EMERGENCY PROCEDURES

11.1 Minor Leaks

A minor leak is a small, slow, controllable release of a compressed gas that poses a low risk of personal injury or exposure. The following outlines an acceptable response to a minor leak:

1. Notify people in the area of the leak, evacuate if necessary, and post signs to prevent others from entering.
2. Wear appropriate PPE for the hazard.
3. If the leak is in the gas supply system, close the valve and attempt to tighten leaking connections.
4. If the leak is at the valve stem, attempt to tighten the packing nut. Be careful not to over tighten.
5. If the leak is at other areas on the cylinder (e.g. valve seal, valve threads, pressure relief device) or cannot be stopped, move the cylinder into a fume hood, under a local exhaust canopy or to an isolated, well-ventilated area to vent cylinder contents.
6. If it is necessary to move a leaking cylinder through populated portions of the building, secure a plastic bag, rubber shroud or similar device over the top of the cylinder to confine the leak.
7. If possible, direct corrosive and toxic gases into an appropriate chemical neutralizer.
8. Notify Public Safety and EHS as soon as possible.
9. Remain outside the immediate area until the cylinder contents have been exhausted.
10. Return cylinder to vendor for repairs.

11.2 Major Leaks

A major leak is a large, uncontrollable release of a compressed gas that constitutes a serious hazard to building occupants, facilities or the environment. If a major leak occurs, initiate the emergency response below.

1. Immediately evacuate the area, shutting doors and windows on the way out, if possible.
2. Pull fire alarm and dial 911.
3. Notify Public Safety and EHS and wait for assistance at a safe location.
4. Ensure that anyone who may have been exposed or contaminated is attended to.
5. Provide all relevant information to authorities upon their arrival.

11.3 Fires

DePaul employees and students should never attempt to extinguish fires caused by a compressed gas unless they have received specific training to do so. If possible, shut off the gas at the source, pull the fire alarm, and call 911 immediately. Notify Public Safety and EHS as soon as possible.

11.4 Defects and Damage

Visually inspect all cylinders frequently for defects or signs of damage. Defective or damaged cylinders must be marked as such immediately and removed from service while the vendor is contacted.

- Bowing vs. Bulging

Bulging is an extremely rare but dangerous condition that may occur in cylinders that have been overheated or when sidewalls are thinned by severe corrosion. A bulge is generally very pronounced and obvious even to the naked eye. There are two basic types of bulges. A long, convex bulge protrudes outward noticeably on one side or around the entire circumference of the cylinder when an entire cylinder has been exposed to high heat. A smaller, goose-egg shaped bulge usually indicates localized overheating, which is the result of "spot annealing."

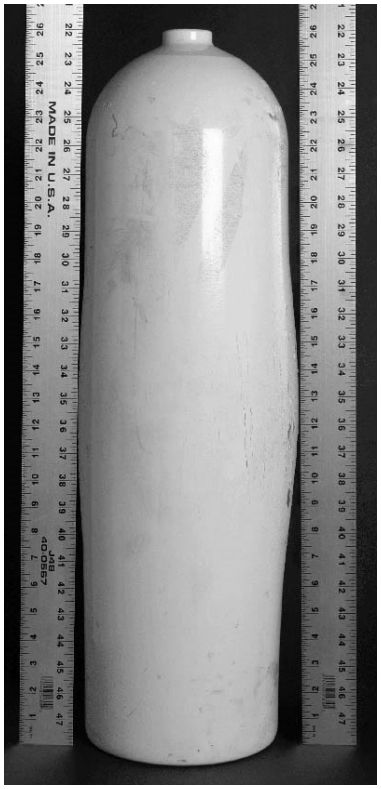
Bulging can be confused with normal cylinder irregularity, which is called bowing. A bow is a slight curve in the cylinder's wall as a by-product of the manufacturing process – it is not a defect. It occurs more often in taller cylinders. A bowed cylinder typically has one convex side curving slightly outward and an opposite concave side curving slightly inward. Less often, a cylinder may have one straight side and one slightly convex side, which is also a type of bow. Most bows are barely recognizable with the naked eye.

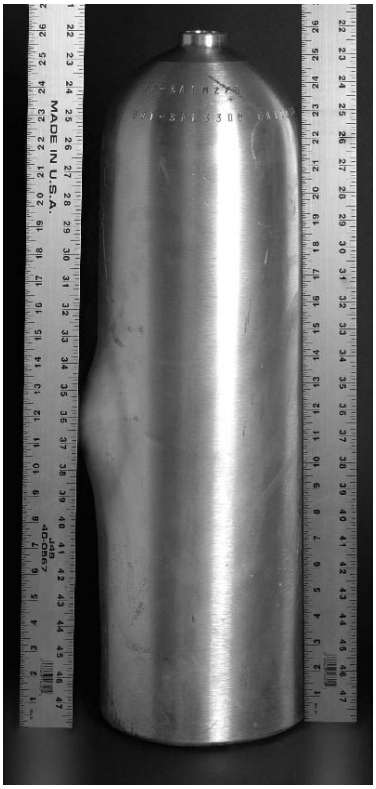
If it cannot be determined whether a cylinder is bowed or bulged, assume it is bulged, remove it from service, and contact the vendor.

See the next page for examples of each.

Bowed Cylinder - **NORMAL**

Bulged Cylinders – **EXTREMELY DANGEROUS**





APPENDICES

APPENDIX A: DEFINITIONS

Compressed Gas: A gas contained at a high pressure that presents a physical hazard and may present one or more specific hazards depending on its composition.

Corrosive Gas: A gas that causes destruction of living tissue upon contact.

> Examples: Chlorine, ammonia, hydrogen chloride, fluorine, hydrogen fluoride, hydrogen sulfide

Flammable Gas: A gas that will burn or explode under certain conditions.

> Examples: Propane, hydrogen, acetylene, ethylene, methylamine, vinyl chloride, methane, carbon monoxide, isobutene

Gas Cylinder: Any compressed gas contained in a metal cylinder. Metal cylinders are the only approved Department of Transportation packaging for compressed gases. Includes lecture bottles (a small cylinder, typically 12–18 inches long and 1–3 inches in diameter) typically used in laboratories and tanks/other containers (e.g. propane, MAPP) used by Facility Operations employees.

Inert Gas: A gas which is chemically inactive (i.e., does not react with other substances).

> Examples: Helium, neon, argon, krypton, xenon, radon

Oxidizing Gas: A gas which may (generally by providing oxygen) cause or contribute to the combustion of other material more than air does.

> Examples: Oxygen, nitrous oxide, chlorine, fluorine, bromine

Pressure Regulator: A mechanical device used to safely control the discharge pressure of a compressed gas from a container.

Pressure Relief Device: A pressure and/or temperature activated device used to prevent the pressure from rising above a predetermined maximum and thereby prevent rupture of a pressurized container.

Pyrophoric Gas: A gas that will spontaneously ignite upon exposure to air (at or below 130° F).

> Examples: Phosphine, silane, disilane, dichlorosilane, borane

Valve: A mechanical device attached to a gas cylinder that permits flow into or out of the cylinder, when the device is in the open position and prevents flow when in the closed position.

APPENDIX B: COMPRESSED GASES IN USE

The following is a non-exhaustive list of compressed gases currently in use on DePaul's Lincoln Park and Loop campuses.

Flammable Gases

Acetylene
Methane/Argon (Only methane is flammable)
Hydrogen
Hydrogen (Ultra High Purity)
Liquefied Ammonia (In tank)
Propane
MAPP

Oxygen Displacing Gases

Carbon Dioxide
Nitrogen
Argon
Helium
Helium (Ultra High Purity)
R-22
R-410A
R-11
R-134A

Oxidizing Gases

Oxygen
Oxygen (Bone Dry)
Nitrous Oxide

No Specific Hazards

Air (Bone Dry)
Compressed Air
R-407A

APPENDIX C: PROGRAM HISTORY

Date	Revision Number	Brief Description of Changes	Review Completed by
April 2017	1	No significant changes	K. Abma

ACKNOWLEDGEMENTS

This manual was developed using best practice examples from Arizona State University, Iowa State University, University of California, Berkeley, Federal and State regulations and guidance documents, NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, and online resources from Luxfer Group and Grainger.