



Compressed Gases and Cryogenic Liquids

Introduction

The term Compressed Gas (CG) refers to gases and mixtures of gases stored under pressure in cylinders. CG can be mainly grouped as Liquefied gases (LG), Non-liquefied gases (NLG) or Dissolved Gases (DG). Cylinders containing compressed gas are used every day on Campus without incident, but these gas cylinders may easily become a serious hazard such as uncontrolled rockets or pinwheels if mishandled or stored improperly. A cylinder with broken valve can easily take off like an uncontrolled rocket or a pinwheel, bounding around the room and even breaking brick walls.

Many compressed gases are toxic or very toxic. They could cause various health problems depending on the specific gas, its concentration, the length of exposure and the route of exposure. Contact between the skin or eye and liquefied gases in liquid form can freeze the tissue and result in a burn-like injury. With the exception of oxygen and air (19.5% O₂), possibly the greatest hazard to the user of CG is asphyxiation. All gas is asphyxiant. If suddenly released, especially cryogenics (*liquefied gases at very low temperatures, having boiling points below -150°C or - 238°F*) such as liquid nitrogen can expand up to 700 times and displace all breathing oxygen, presenting a serious asphyxiation hazard. Also, it can create a highly visible fog (due to condensation of moisture in the air), which may obscure emergency EXIT path.

Proper Handling, Storage, and Use

To ensure safety of life and property, all compressed gases and cryogenic liquids shall be stored, handled and used in accordance with the requirements of the applicable New Jersey Uniform Fire Code (NJUFC), NFPA 45 and the University's Laboratory Safety Plan to minimize the hazards of fire, explosion and personal injury. Each department or laboratory storing or using compressed gases and cryogenic liquids shall, at a minimum, ensure that:

- A. All employees have **adequate knowledge and training** regarding safety and first-aid procedures for gases being used or handled. Employees should be provided with and encouraged to read and follow the instructions on the warning labels, review applicable Safety Bulletins and Material Safety Data Sheets (MSDS) for specific gases.
Ref: NFPA 45:11.1.1
- B. All individuals working on or near CG systems wear **eye protection at all times and wear protective gloves**, particularly when handling cylinders containing cryogenic (super-cold) gases.
- C. **Maximum number of CG cylinders in a laboratory** is limited to a two-month supply. Cylinders not 'in use' are not be stored in the laboratory. A single cylinder secured alongside the cylinder in use as the reserve cylinder is considered 'in use.' (NFPA 45:11.1.6. 3 & 4). Flammable compressed gas cylinders (e.g., *acetylene, butane, ethylene, hydrogen, methylamine and vinyl chloride*) in laboratories are limited to only those in current use. The maximum quantities of compressed gases and cryogenic liquids shall never exceed those specified by the NJUFC or other applicable Fire Code. When noncompliance is identified during lab safety audit or fire code inspection, EOHSS will work with the appropriate Department Manager to resolve this issue in accordance with the applicable fire code requirements.



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- D. **Excess cylinders and tanks** are stored in a separate ventilated room approved for that use.
- E. **All cylinders (in service or storage, full or empty)** are:
1. Adequately secured with chains or straps positioned around the upper third of the cylinder, or by proper nesting to prevent falling or being knocked over.
 2. Protected with valve protective caps in place until the gas is about to be used.
 3. *Never* stored in any portion of an exit or common corridor, elevator car or in space under the stairway. A CGC or a cryogenic container shall not be located such that it could prevent safe egress in the event of accidental release of their contents unless a second means of access to an exit is available from a laboratory work area.
 4. Stored away from elevators, staircases or main traffic areas to avoid dangerous impediments.
 5. Promptly moved to their designated storage area once delivered.
 6. Removed *within one day*, when placed in the hallways for pickup.
 7. Moved with a suitable hand cart and never allowed to be dropped or banged together violently.
 8. Kept away from fire, heat and spark-producing operations.
 9. Grouped according to their properties. Do not store flammable gases next to exit or oxygen cylinders.
 10. Stored such that flammable gases are separate from oxidizing gases, and empty cylinders are separate from the full cylinders. *Note: Oxidizing gases contain oxygen at higher than atmospheric concentrations (above 23-25%). Common examples are: nitrogen oxides, halogen gases such as chlorine and fluorine.*
 11. Properly marked with the name of the contained gas. Don't accept unidentified cylinders and don't rely on color codes; read the label.
- F. **Use Safety: Each department or laboratory** shall ensure that:
- ♦ A CG cylinder is never used without a pressure-reducing regulator that safely reduces the cylinder pressure to the required level.
 - ♦ Only those regulators are used that have both high-pressure gauge and a low-pressure gauge to be able to monitor both the pressure in the cylinder and in the system.
 - ♦ Never use a pressure gauge above 75% of its maximum face reading. Immediately replace any gauge whose pointer does not go back to its zero point when pressure is removed.
 - ♦ Cylinder valves are cleaned of any dust or dirt before attaching proper regulators.
 - ♦ Cylinder valve is closed properly and the protective cap is replaced before returning the cylinder.



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- ♦ Adjusting screw is released on regulator before opening cylinder valve.
 - ♦ An adaptor is never used between a cylinder and a pressure-reducing regulator.
 - ♦ Regulators are never interchanged. Some regulators are only for specific gases.
 - ♦ Excessive force is never used to connect a CGA connection.
 - ♦ Safety devices in cylinder valves or regulators are never tampered.
 - ♦ Any damaged cylinder or valve is immediately reported to the supplier and to the Campus emergency number.
 - ♦ Any aid, such as pipe dope or Teflon tape, is never used to connect a regulator to a cylinder.
 - ♦ The users are trained to stand to the side of the regulator when opening cylinder valve and open the cylinder valve slowly.
 - ♦ The users are instructed never to transfer CGs from one container to another, refilled or sucked back into the cylinder.
 - ♦ Separate empty and full cylinders during storage. Mark empty cylinders "EMPTY" or "MT". *Note that a cylinder with a pressure gauge reading of 0 psig (0 kPa) is not really empty. It still contains gas at atmospheric pressure. [Gauge pressure = Total gas pressure inside cylinder – atmospheric pressure (14.7 psi or 101.4 kPa)].*
 - ♦ Use Safety Tips for Compressed Gas Users in Annex F of NFPA 45, 2004 edition, as applicable.
- G. **Cryogenic liquid** (*liquefied gases at very low temperatures, having boiling points below -150°C or -238°F*) **tanks** are checked periodically to ensure that they:
1. Have not lost vacuum or insulation (a cold outside jacket of the tank indicates the need for tank service),
 2. Are checked at the neck of the tank opening for any ice accumulation to prevent any blockage and subsequent pressure buildup within the container,
 3. Are checked for sabotage of the pressure relief devices on the tank.

The following two **safety precautions** must be taken with cryogenic gases:

1. Use protective gloves and eye wear when handling cylinders containing cryogenic (super-cold) gases.
2. Where cryogenic gases are vented or released at a rate anything more than a few cubic centimeters of gas per minute inside of an area, adequate 24-hour ventilation is required. Install continuous oxygen monitor(s) with a 'low oxygen' alarm in such areas for safety.



Important Definitions

- a. **Compressed Gas** (CG) refers to gases and mixtures of gases stored under pressure in cylinders. CG can be mainly grouped as Liquefied gases (LG), Non-liquefied gases (NLG) or Dissolved Gases (DG).
- b. **LG** are gases which can become liquids at normal temperatures when they are inside cylinders under pressure. *Anhydrous ammonia, chlorine, propane, nitrous oxide and carbon dioxide* are examples of liquefied gases.
- c. **NLG** are permanent gases that do not become liquid when they are compressed at normal temperatures, even at very high pressures. Common examples of NLG are *oxygen, nitrogen, helium and argon*.
- d. **Acetylene gas** is chemically very unstable and can explode even at atmospheric pressure, and therefore used as a Dissolved Gas (DG). When added to the cylinder that is fully packed with inert, porous filler saturated with acetone or other suitable solvent, it dissolves in acetone and becomes a stable acetylene solution. Acetylene is routinely stored and used safely in cylinders at high pressures (up to 250 psig at 21°C).
- e. **Flammable Compressed Gases** (FCG) such as *acetylene, butane, ethylene, hydrogen, methylamine and vinyl chloride* can burn or explode under certain conditions. All ignition sources (open flames, sparks and hot surfaces) must be kept away from FCG. Many FCG, being heavier than air, can settle and collect in poorly ventilated area, sewers, pits, trenches, basements or other low areas, if leaked. Once the gas reaches an ignition source, the fire produced can flash back to the cylinder.
- f. **Oxidizing compressed gases** (OCG) containing oxygen at higher than atmospheric concentrations (above 23-25%) are *nitrogen oxides, halogen gases such as chlorine and fluorine*. OCG can cause fires or explosions since they react violently with combustible materials such as: (a) organic (carbon-containing) substances such as most flammable gases, flammable and combustible liquids, oils, greases, many plastics and fabrics; (b) finely-divided metals and (c) other oxidizable substances such as hydrazine, hydrogen, hydrides, sulphur or sulphur compounds, silicon and ammonia or ammonia compounds.
- g. **Dangerously Reactive Compressed Gases** (DRCG) are chemically unstable in their pure form. If exposed to slight temperature or pressure increases, or mechanical shock, they can readily undergo certain types of chemical reactions such as polymerization or decomposition. These reactions may become violent, resulting in fire or explosion. Some dangerously reactive gases have other chemicals, called inhibitors, added to prevent these hazardous reactions. Common dangerously reactive gases are *acetylene, 1,3-butadiene, methyl acetylene, vinyl chloride, tetrafluoroethylene and vinyl fluoride*.
- h. **Inert compressed gases** (ICG), such as *argon, helium, neon and nitrogen*, are not toxic and do not burn or explode. Yet they can cause injury or death if they are present in sufficiently high concentrations. They can displace enough air to reduce oxygen levels. If oxygen levels are low enough, people entering the area can lose consciousness or die from asphyxiation. Low oxygen levels can particularly be a problem in poorly ventilated, confined spaces.
- i. **Corrosive compressed gases** (CCG) such as *ammonia, hydrogen chloride, chlorine and methylamine* can burn and destroy body tissues on contact. They can also attack and corrode metals.

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