

Compressed Gas Safe Handling and Usage Guidelines

In accordance with WAC 296-24-68203- [References](#)

The document is intended to be used as a reference and in no way does this replace a personal training session regarding compressed gas safe handling and usage.

1. Objectives

After completing the in person lab training and reading this document you will be able to:

- Define/identify a compressed gas cylinder
- Understand the labels and markings affixed to a cylinder
- Understand the safety hazards related to compressed gas cylinders
- Understand the safety hazards associated with different gases
- React in a safe manner to an accident or failure involving a compressed gas cylinder
- Be able to safely store and transport a compressed gas cylinder
- Be able to safely remove and attach a compressed gas regulator
- Be able to safely operate a compressed gas regulator for the purpose of expelling the contained gas for the necessary and approved usage

2. Defining and Identifying Cylinders

2.1. Compressed Gas

A compressed gas is defined as a non-liquefied gas. This means that they do not become a liquid at room temperature, even when at high pressure. This can include:

- A gas or mixture of gases in a container with an absolute pressure greater than 40 psi at 70 °F (21 °C)
- A gas or mixture of gases in a container with an absolute pressure greater than 104 psi at 130 °F regardless of pressure at 70 °F (21 °C)
- A liquid having a vapor pressure exceeding 40 psi at 100 °F (38 °C): as determined by ASTM D-323-72

Examples include: helium, nitrogen, oxygen, and argon.



2.2. Refrigerated Liquefied Gases (Cryogenics)

The class of gases that are referred to as refrigerated liquefied gases are also known as cryogenics. They are:

- Kept at very low temperatures.
- Extremely cold with boiling points below minus 150 °C.
- Heavier than air under cold temperature conditions and can accumulate near the floor.
- Able to expand into very large volumes of gas from small amounts of refrigerated liquefied gas liquid.



Examples of refrigerated liquefied gases (cryogenics) include: helium, liquid nitrogen, and liquid argon. Carbon dioxide and nitrous oxide, which have slightly higher boiling points, are also included in this category.

Bulk storage and container transport of cryogenic gases is in liquid, double-walled, vacuum-sealed containers that can be either *pressurized* or *non-pressurized*.

Pressurized containers have vents, dispensing hoses, and pressure gauges. Pressure relief valves are spring loaded devices set at a specific pressure that relieve excessive pressure, reclose and reseal to prevent further release of product.

Non-pressurized containers are typically open-topped vessels or Dewars with loose fitting covers to minimize evaporation or off gassing and range from one to 50 liters in size.



2.3. Dissolved Gases

This class of gases that are referred to as dissolved gases are those that are dissolved in another substance.

Acetylene is the only commonly used dissolved gas and it is dissolved in acetone. It is chemically unstable and flammable.

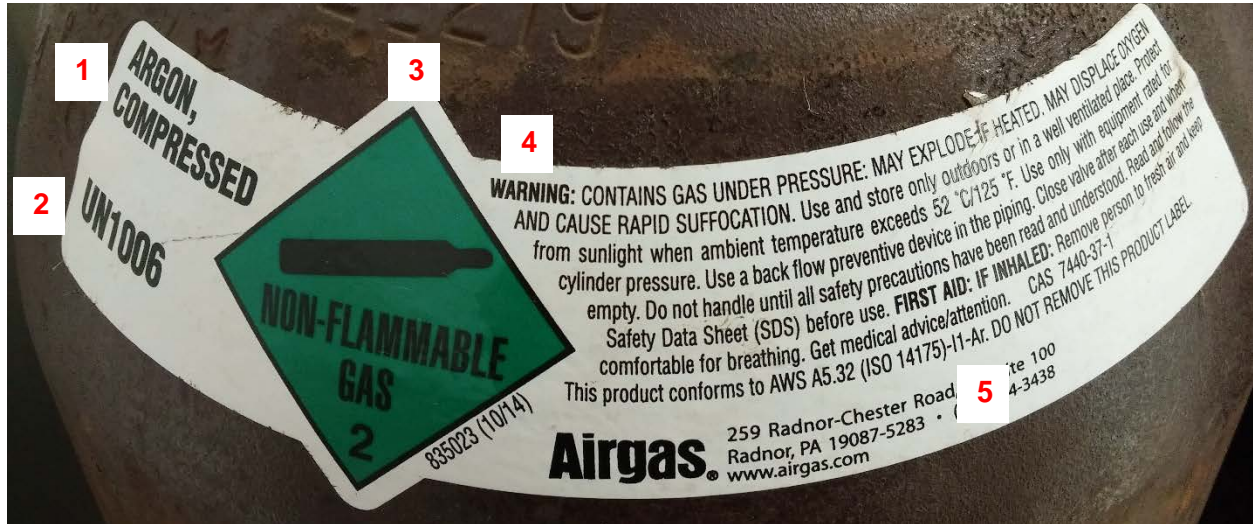
2.4. Classification

Gases are classified in different ways according to definitions by different regulations including Department of Transportation (DOT) and Fire Code regulations as well as by classification systems such as the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). These classifications are different and overlap in some ways. Users should be aware of all the hazards associated with the gases they are using. The links below are to the Fire Code definitions for compressed gases Web page and GHS and DOT definitions with pictograms to help identify how chemicals are classified.

[Fire Code Definitions for Compressed Gases](#)
[GHS-DOT Classification Comparison Chart](#) (PDF)

2.5. Labeling

Cylinders must always be labeled correctly. If there is an unlabeled or improperly labeled cylinder, contact the person in charge of that cylinder immediately and notify them of the hazard. The labeling must comply with United States Department of Transportation (US DOT) and Occupational Safety and Health Administration (OSHA) regulations. Never remove or deface the labels on a cylinder. Below is an example of how to read a tag.



1. Name of Gas (does not include purity rating, this is located elsewhere on the cylinder).
2. UN number. Used to identify the material.
3. Hazard diamond which indicates the flammability and/or toxicity of the gas.
4. Warning section. Includes hazard associated with the gas and cylinder.
5. First aid. Tells how to help treat someone who has suffered from exposure to the gas. Always call 911 when a person has been affected. Ensure a safe area before approaching a person who appears to have been affected.

2.6. Cylinder Status Tag

When using a cylinder, take note of the tag. It should look similar to the one in the image to the right. When opening up a new cylinder, the full section must be torn off. When a cylinder is moved to storage partially full, the remaining pressure should be written next to the part full portion. When a cylinder runs empty, the part full portion must be removed and the cylinder should be safely moved to storage. See [Section 6. Storage and Transportation of Cylinders.](#)



3. General Safe Handling

Compressed gas cylinders must be handled with caution at all times. It is particularly important to protect cylinder valves from breakage and store gas cylinders upright. The following are safety and handling instructions:

3.1. Do's:

- Make sure cylinders have proper labels including: contents, concentrations, hazard classifications, safety precautions, manufacturer or supplier's name, and a tag that indicates whether the cylinder is full, in-service, or empty. Accept only properly identified cylinders. If the cylinder is not properly labeled or the label cannot be read, return the cylinder to the supplier.
- Make sure gas cylinders are not damaged and do not show signs of corrosion. If you notice that they have damaged labels, dents, gouges, burn/heat marks, or show signs of corrosion, then do not accept them and return them to the supplier.
- Assume all cylinders contain gas under pressure and treat all gases as hazardous chemicals.
- Label all gas lines leading from gas cylinders clearly.
- Use, store, and transport cylinders in an upright position unless they qualify to be stored horizontally. (See Storage section below for more information.)
- Use cylinders in a well-ventilated area. If you need to use a gas cylinder in spaces with inadequate ventilation confer with EH&S (206)543-7388 to conduct a hazard assessment. Spaces with inadequate ventilation may need oxygen alarms or ventilation failure alarms.
- Move cylinders with a cart or hand truck designed for strapping on cylinders.
- Secure cylinders properly during storage, transport, and use so that they cannot be knocked over.
- Make sure caps are in place when the cylinder is not in use and during transport.
- Make sure access to the cylinder valve is unobstructed at all times.
- Make sure pressure regulators are equipped with pressure release valves.
- When turning off the cylinder, turn the gas supply off at the cylinder valve first, depressurize the system, and turn off the regulator.
- Keep incompatible gases stored separately. If the cylinder is not in use, separate oxidizing gases from flammable gases by 20 feet or a one-hour firewall. Note: one backup cylinder stored in the area with the one in use may also be considered to be "in use" and not subject to incompatibility storage requirements. (See Compatibility section below for more information.)
- Store highly toxic gases in exhausted enclosures (gas cabinet or fume hood).
- Avoid sources of ignition and open flame.

3.2. Do NOT's:

- Do NOT purchase more or larger cylinders than necessary.
- Do NOT store flammable gases next to an exit or near oxygen cylinders.
- Do NOT use or permit contact of oil or grease on cylinders or their valves.

- Do NOT empty gas cylinders to a pressure lower than 25 psi (172 kPa). At lower pressures, suction and backflow can cause contamination of residual contents with air if the valve is open.
- Do NOT use Teflon tape on cylinder or tube fitting connections, which have metal-to-metal face seals or gasket seals.

3.3. Personal Protective Equipment (PPE)

When using gas cylinders, make sure to wear closed-toe shoes, and safety glasses.

Refrigerated Liquefied Gas/Cryogen PPE

- Wear insulated, cryogenic gloves when handling cryogens
- Wear protective eyewear and face shields
- Wear smock or lab coat

Tailor PPE requirements to each hazard.

3.4. Compressed Gas Piping and Tubing

3.4.1. Permanent Gas Piping Systems

- Installed by qualified personnel
- Durable and heat resistant materials
- Steel, copper, stainless steel tubing/pipe
- Fuel gas Grade T flexible gas tubing with appropriate hose clamps must be used for all petroleum-based products
- Piping material must be compatible with gas
- Components: Shut off valves, point of use valves, regulators and pressure relief valves
- Appropriate labeling
- May serve an entire building

3.4.2. Temporary Gas Piping Systems

- Piping/tubing runs should be as short as possible
- Piping may not serve other rooms
- Appropriate plastic and soft copper tubing acceptable
- Piping material must be compatible with gas
- Regulator must step down pressure significantly for piping system
- Tubing/piping may not be charged (pressurized) when unattended
- It is only used for short term, experimental process development
- Appropriate labeling
- Only experienced lab staff should operate the system

- Pipelines can suffer pressure changes depending on the ambient temperature resulting in an over-pressurization and must include a pressure relief device.

- Pipelines must include appropriate labeling, zone shut-off valves, and methods for venting lines between regulators and shut-off valves.

- Do NOT use copper fittings and tubing on acetylene cylinders.

4. Hazards of Compressed Gases

There are many hazards associated with the use of compressed gases.

- The **high pressure** in cylinders (4.4 to 6,000 psig) makes the gas cylinder a potential physical explosive that could punch through walls.
- Some gases may be **corrosive** which could result in damage to tissue and/or equipment at the point of contact leading to severe injury and potentially loss of life.
- **Cryogenic** gases have dangers of low temperature, potential frostbite, and they may expand into large volumes of gas that could displace oxygen and result in suffocation.
- Inert gases and oxidizing reactions may create **oxygen deficiency hazards (ODH)** by displacing oxygen and may lead to suffocation. The early symptoms may be dizziness and weakness, which may lead to unconsciousness and loss of life. This is also termed asphyxiation.
- **Flammability** is a concern especially with the gases acetylene, hydrogen, and propane.
- The permissible exposure limits for toxic materials is very low and so even small exposure is considered to be **poisonous**. Cylinders should always be tested for leaks to prevent such hazards.
- Oxygen leaks may create **oxygen enriched atmospheres** which increase the risk of fire and explosions. See a video link demonstrating the hazard [here](#).
- See additional hazards as listed on **Safety Data Sheets (SDSs)**. SDS sheets are available online [here](#) as well as on the desktop of every laboratory computer on campus.

5. Emergency Procedures

In the event of a compressed gas cylinder failure or leak, follow this procedure:

1. Leave the area immediately to a well ventilated area far from the leak.
2. Notify any nearby persons to also evacuate the area immediately due to the failure or leak.
3. Call 911 and report the problem.
4. Contact the owner of the cylinder or laboratory.
5. DO NOT attempt to remedy the leak or failure.

6. Storage and Transportation of Cylinders

The storage and transportation of cylinders are guidelines to ensure the safety of all persons. This is to prevent accidental cylinder failure which may result in injury or loss of life or property damage. The following guidelines should be strictly adhered to.

6.1. Storage

1. The cylinder must be in good condition with an operable valve. Cylinders not in use should be capped.
2. Compressed gas cylinders should be stored in an organized, ventilated, well-lit place away from combustible materials.
3. All gas cylinders must be stored upright and firmly secured to a wall.

4. Do not remove or damage manufacturer applied labels, decals, or cylinder content information.
5. Any storage area must be protected from excessive heat, open flame, or ignition sources.
6. Storage outside should be above grade, dry, and protected from weather conditions.
7. Store cylinders so oldest products get used first.
8. Compressed gas containers, cylinders and tanks must be stored in the upright position.

There are two exceptions:

- a. Containers designed for use in the horizontal position
- b. Compressed gas containers with a water volume less than 5 liters are allowed to be stored in the horizontal position

An example of a cylinder that may be stored horizontally is a lecture gas cylinder.

6.2. Securing Cylinders

In Place:

- Secure the container with a bracket, chain, strap, or other approved restraint to a fixed object, such as a wall or bench, with one or more restraints.
 - One strap or chain meets the minimum requirement.
 - Two straps are recommended or chains located at 1/3 and 2/3 of the cylinder height above the floor because cylinders secured by a single strap have been found to escape the strap during an earthquake.
- A cart, hand truck, or other mobile device does not meet the requirement of securing a cylinder for use and should never be used in such a manner.

In Motion:

- Secure the container to a cart, hand truck, or other mobile device designed for the movement of compressed gas containers, cylinders, or tanks.

6.3. Compatibility

Gas types should be separated from incompatibles and the areas clearly marked. Guidelines are as follows*:

- Keep incompatibles a distance away of not less than 20 feet or use noncombustible partitions extending not less than 18 inches above and to the sides of the containers, cylinders, or tanks.
- Use approved storage cabinets or exhausted enclosures.

* Exception includes: cylinders in use including one spare backup cylinder stored in the same location and of the same composition as the cylinder in use.

Consideration should also be given to using compatible materials for containers, tubing, and reaction vessels. Several compatibility guides are available on the Web, such as [here](#).

6.4. Flammable and Poisonous (Toxic, Highly Toxic) Gas Specifics:

- Store and use flammable gas cylinders in adequately ventilated areas segregated from other gases.
- Store and use poisonous (toxic, highly toxic) gas cylinders in a gas cabinet or exhausted enclosure. A chemical fume hood may be acceptable for lecture and other small bottles. Confer with EHS.
- Toxic and highly toxic cylinders must be provided with a restriction orifice by the vendor.
- Respirators may be necessary when working with poisonous (toxic, highly toxic) gas. Contact EHS for evaluation.

6.5. Transportation of Cylinders

Always remove the regulator and cap a cylinder before you move it. Cylinders must always be transported using a hand truck or cart designed for that purpose. Safety glasses and closed toe shoes should be worn when handling cylinders.

When moving compressed gas cylinders:

- Have the metal outlet cap/plug installed,
- Have the valve cap installed if the cylinder has one, and
- Secure cylinders in a cart or container designed to prevent the cylinder from falling over while being moved.
- Use service or freight elevators.

6.5.1. Additional requirements for gas cylinders and cryogenics:

Transport gas cylinders and cryogenics (for example, liquid nitrogen) using one of the following methods:

- Exclude people from the elevator by posting a sign on the cart carrying the cylinder. The sign should read “**Do Not Enter. Compressed Gas Transport.**” Ideally, someone sends the elevator up and another person waits on the receiving floor to take the cylinder or cryogenics out of the elevator. If this is not possible then another plan should be devised to ensure that the cylinder or cryogen is taken out of the elevator once it reaches the needed floor.

7. Regulators

A regulator is a device that lowers the pressure in the cylinder to a usable level. Typical pressure inside a cylinder can be anywhere from 40 psi up to 6,000 psi. Therefore, a cylinder should never be opened without a properly secured regulator.

There are two kinds of pressure regulator designs which appear similar: single and two stage.

- Single stage regulators are used when precise control of delivery pressure is not required and are good for short-term usage.
- Two-stage regulators give precise control and are good for long-term usage.

- Keep regulators clean, free of surface oil and grease. (Especially oxidant gases).
- Always use the proper regulator for the gas in the cylinder. Connection fittings, stamped CGA numbers, plaques, and/or decals on the regulator indicate which gas the regulator is designed for.
- Do not use Teflon® tape, putty, or other such materials on the threads unless specifically required (or applied) by the manufacturer/vendor.
- A volume restriction orifice installed downstream of the regulator is required for all toxic and highly toxic gases. Specify pressure and flow requirements when ordering compressed gas so that the vendor provides the proper restriction orifice.
- When not in use. The gas should be turned off at the cylinder and the regulator adjustment knob should be turned counterclockwise to achieve an output pressure on zero. Ensure that at least two threads are left in the valve body.

7.1. Changing a Cylinder

When a cylinder runs empty, it may be necessary to change it out for another cylinder of the same composition. If it is a different composition, check the compatibility of the new gas mixture with the previous gas mixture as well as compatibility with the regulator and tubing infrastructure. See [Section 6.3. Compatibility](#).

When a cylinder runs empty and you are positive that the replacement cylinder is compatible with the current setup:

1. Remove the part full section of the cylinder status tag.
2. Close the cylinder valve.
3. Vent the pressure in the line safely.
4. Set the pressure of the regulator to zero by turning the adjusting knob or handle counterclockwise. It is important that at least two threads remain engaged into the regulator body.
5. Close the outlet valve.
6. Remove the regulator with a regulator wrench, and open end wrench, or an adjustable wrench by turning counterclockwise.
7. Carefully place the regulator in a position that it will not fall or place strain on the tubing attached.
8. Place the cap on the cylinder ensuring to tighten it all the way down.
9. Unstrap the cylinder and place it on a hand truck or cart designed for transporting cylinders and strap it down.
10. Move the cylinder to the storage location and strap it down. Notify the person who manages the inventory when a cylinder runs empty that needs to be replaced.
11. Obtain the cylinder that is to be placed in the desired location and hooked up.
12. Unstrap the cylinder and place it on a hand truck or cart designed for transporting cylinders and strap it down
13. Move the cylinder to the operating position and strap it down.
14. Remove the cylinder cap. This can sometimes be difficult. A strap wrench may be used to facilitate the cap removal. If it is too difficult. Try a different cylinder of the same type or ask the facility manager for help.



15. Ensure that the regulator pressure has been set to zero by turning it counterclockwise. It is important that at least two threads remain engaged into the regulator body.
 16. Visually inspect the regulator fitting and fitting surface of the cylinder for damage or debris.
 17. Remove any loose debris from the threads and the seat and do not use if damaged. DO NOT open the cylinder valve to remove debris!
 18. Prior to affixing the regulator, ensure that you and other persons are not in the path that the cylinder outlet is facing.
 19. Affix the regulator by first manually tightening the fitting followed by using a regulator wrench, and open end wrench, or an adjustable wrench by turning clockwise.
 20. Tighten until snug. NO NOT overtighten. This may damage the fittings.
 21. Never use any type of thread sealant on the regulator or cylinder.
 22. Open the cylinder valve. The right gauge on the regulator should show the pressure inside the cylinder.
 23. Open the outlet valve.
 24. Turn the regulator's adjusting knob or handle clockwise to raise the delivery pressure to the desired value while watching the delivery gauge on the left. DO NOT exceed the maximum delivery pressure for the regulator or the system.
- If only removing a cylinder, steps 1 – 10 can be utilized independently of the entire procedure.
- If only placing a cylinder in service, steps 11 – 24 can be utilized independently of the entire procedure.

8. References

- [University of California Berkeley](#)
- [University of Washington](#)
- [NFPA 55 – Compressed Gas and Cryogenic Fluids Code](#)
- [OSHA – Compressed Gasses](#)
- [WAC 296-24-68203](#)
- [Department of Transportation - 49 CFR 173.301](#)
- ASTM D-323-72
- ASTM E681-85