Compressed Gas Cylinder Standard

Section:	Laboratory Safety Manual	Issued by:	Environment, Health and Safety
		Issued Date:	2009.01.12
Part:	Chemical and Laboratory Safety	Revised Date:	2022.03.01
		Reviewed Date:	
Pages:	27	Revision #:	2
		Revised by	JD, JW

PURPOSE

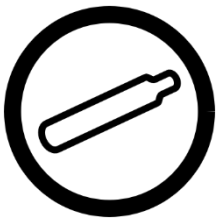
Compressed gases are routinely used in laboratories across the University of Calgary campuses, and have the potential to create hazardous working environments. A leaking cylinder can produce an atmosphere that is toxic, oxygen-deficient or explosive; may be immediately dangerous to life or health, and may be reactive with other substrates in the environment. In the event of rapid release, the cylinder can also become an unpredictable projectile. Therefore, preventing the uncontrolled escape of gas is the main goal of safe procedures for handling, use and storage of compressed gas cylinders.

This Standard contains information on the safe handling, use and storage of compressed gas cylinders to protect people, assets and the environment. The information within this document addresses legislated requirements as found in the following regulations, codes and standards: Alberta Occupational Health and Safety Code, National Fire Code-Alberta Edition, National Fire Protection Association Code, and Transportation of Dangerous Goods. These requirements and guidelines must be reviewed by all workers prior to starting work involving compressed gas cylinders and may be used in the development of individual site-specific Standard Operating Procedures.

SCOPE

This Standard applies to all persons handling, using, or storing compressed gas cylinders under the auspices of the University of Calgary. This includes all liquefied, non-liquefied and dissolved gases stored under pressure within cylinders of all sizes.

PROPERTIES & HAZARDS



WHMIS 1988

WHMIS 2015

Compressed gases are classified based on type of hazards in the Hazardous Products Act (Schedule 2), the Hazard Products Regulations (Part 7 – Physical Hazard Classes), and under the Transportation of Dangerous Goods Act (Class 2). These classifications are based on the hazard of the contents being under pressure, and further physical and/or health hazards dependent on the properties of the gas itself.

- **Fire and explosion** – combustible, flammable, pyrophoric and oxidizing gases can burn, explode or intensify a fire under certain conditions.
- **Health hazards** – many gases are toxic and can cause serious health problems.
- **Chemical burns** – some gases are corrosive and can burn or damage the skin, eyes or lungs on contact.
- **Asphyxiation** – some gases, once released, can displace oxygen in the area to below what is required to support consciousness.
- **Extreme Cold** – gas escaping the cylinder may be very cold and can cause burns upon contact with skin.
- **High Pressure** – damaged cylinders can become projectiles upon rapid uncontrolled release of gas.
- **Injection** – gas escaping from pinhole leaks can be injected into the body when skin is in direct contact with the leak.
- **Manual Handling** – gas cylinders are heavy and awkward to handle, and may lead to musculoskeletal or crushing injuries.

RESPONSIBILITIES

Managers/Supervisors/Principal Investigators (PIs)

- Managers, Supervisors and PIs are responsible for facilitating the protection of the health and safety of people within their areas of responsibilities as per UCalgary OHS Policy.
- Utilize the Hazard Assessment and Control form (HACF) to identify and communicate hazards related to the tasks being performed and implement the necessary controls.
- Develop a written Standard Operating Procedure (SOP) detailing the specific procedures for use, handling, and storage of hazardous compressed gases used in their laboratory or workspace.
- Ensure that workers are trained and competent prior to commencing work.
- Ensure that safe work practices for compressed gas cylinders are followed in their area.

Workers

- Review this standard prior to working with compressed gases.
- Review the Safety Data Sheet (SDS) for the compressed gas in use.
- Follow the guidelines and requirements set out in this standard and any additional requirements determined by the Principal Investigator or supervisor in regard to compressed gas cylinder handling, use, and storage for their area.
- Report hazardous conditions immediately to their supervisor.
- Wear and properly maintain the required personal protective equipment (PPE).

Facilities

- Develop and implement design guidelines compliant with appropriate legislation, codes, standards and best practices affecting construction and renovations in areas where compressed gas will be used or stored.

Environment, Health and Safety (EHS)

- Provide information to lab users on appropriate legislation, codes, standards and best practices for use, handling and storage of compressed gas cylinders.
- Assist departments with interpretation and methods of compliance with this standard.
- Periodic review and revision to this standard.

Table of Contents

USE & HANDLING

Workers must be familiar with the hazards of compressed gases and trained by competent laboratory personnel in the proper handling of compressed gas cylinders. Compressed gas cylinders are heavy and difficult to move, and mishandling can result in injury and/ or hazardous gas release. Refer to Table 1 below for the hazard classifications of different types of compressed gases, common examples, a general description and general safety considerations. Always review the Safety Data Sheet (SDS) for the compressed gas in use and ensure the HACF appropriately identifies the hazards and controls in place. For a list of required and recommended controls pertaining to compressed gas usage, refer to UCalgary Fixed Gas Detection (FGD) Determination Process and FGD Controls Table.

Table 1. Types of compressed gases.

Type (Hazard Classification)	Description	Example	Safety Considerations
Pressurized Gas 	Includes liquefied, non-liquefied and dissolved gases.	Any gas compressed in a cylinder	Handle with care. Contents under high pressure. Cylinders can be heavy.
Inert Gas 	Gases that do not react with other material at normal pressure and temperature.	Carbon dioxide Nitrogen Helium Argon	While minimally reactive, may still displace oxygen in air and cause suffocation.
Flammable Gas 	Gases that may ignite resulting in fire or explosion.	Hydrogen Acetylene	Keep separate from oxidizing gas, open flames/sources of ignition and other flammable substances.
Oxidizing Gas 	Gases that may enrich combustibles or intensify a fire or explosion.	Oxygen Nitrous oxide Chlorine	Keep separate from flammable gas and combustible substances. Must be kept free of oil and grease.
Corrosive Gas 	Gases that may damage metals, fabrics, plastics and human tissue, causing burns and irritation.	Ammonia Hydrogen chloride Hydrogen fluoride Sulphur dioxide	Work requires ventilated gas cabinet. Emergency station must be within 7.5 m.
Toxic Gas 	Gases that are fatal or harmful if inhaled, as defined by LC50 value.	Carbon monoxide Chlorine Hydrogen sulphide	Work requires ventilated gas cabinets.
Pyrophoric Gas 	Gases that will ignite upon contact with air or moisture.	Silane Phosphine Arsine	Not permitted in non-sprinklered areas. Work requires sprinklered and ventilated gas cabinet.
Cryogenic Gas 	Gases that are extremely cold at atmospheric pressure.	Liquid nitrogen Liquid helium Liquid argon	May cause oxygen-deficient environments upon release, or condense oxygen in the air to create a combustion hazard.
Liquefied Petroleum Gas (LPG) 	A flammable mixture of hydrocarbon gases	Butane Iso-butane, Propane Propylene Butylene	Denser than air - may settle and accumulate. Must not be stored in flammable cabinets, within 6 m of flammable liquids, or within 3 m of a flammable liquid storage cabinet.

A flowchart summarizing the safety considerations can be found in the Appendix (Figure 10).

Movement of Cylinders

The movement of compressed gas cylinders within buildings on campus must adhere to the following requirements:

- UCalgary Movement of Hazardous Materials within Buildings Guidelines must be followed.
- Only move cylinders, even for short distances, with the regulator removed, the cylinder valve closed, and the valve protection device (Figure 1) in place.
- Cylinders are to be moved in an upright position using a cart designed for that purpose and only with the securing strap or chain in place (Figure 2).
- Be attentive and in full control of cart when moving compressed gas cylinders.
- Consider using a buddy system to move compressed gas cylinders and when using an elevator:
    - Have one person load the secured cylinder on the cart onto the elevator, select the destination floor and exit before it departs. Place a warning sign at entrance of the elevator (e.g. Danger - Do not enter) if available.
    - The second person awaits the arrival of the elevator at the destination floor level to retrieve the cylinder on cart and warning sign.
- Restrict repositioning of compressed gas cylinders within the work area to distances of less than 2 metres. Moving over a distance greater than 2 m requires a cart.
- Do not drag compressed gas cylinders.
- Do not lift or move compressed gas cylinders by the valve protection device.
- Do not drop or strike compressed gas cylinders.
- Leave valve protection device (Figure 1) in place until the compressed gas cylinder is secured and ready to be used with a regulator.
- Never tamper with pressure relief devices in valves or cylinders (see Figure 3 for cylinder components).

Figure 1. Examples of cylinder valve protection devices: Valve guards (left, middle) and valve cap (right).[1]

[1] Air Liquide Smartop™; British Compressed Gases Association; Air Liquide Healthcare Canada

Figure 2. Example of suitable carts with chain for movement of compressed gas cylinders.[2]

Figure 3. Example of compressed gas cylinder components. Top: Cylinder with a hand wheel-type regulator valve. Bottom: Cylinder with a lever-type regulator valve.[3]

[2] Air Liquide Canada; Denios Canada.
[3] Air Liquide Smartop™.

The movement of compressed gas cylinders by vehicle, or on public roads, is considered transportation and is subject to Transportation of Dangerous Goods (TDG) legislation.

- Private vehicles are not to be used to transport compressed gas cylinders.
- If a compressed gas cylinder needs to be transported by vehicle between campuses contact the supplier for assistance.
- Contact Hazardous Materials Services for more information on TDG requirements.

Cylinders in Use – General Requirements & Guidelines

All users of compressed gas cylinders must maintain their on-site inventory of cylinders to as low as reasonably practicable. Laboratories are not permitted to store cylinders, only those cylinders which are "in-use" may be in the lab. Compressed gas cylinders that are kept on site are to be inventoried in Chematix (see UCalgary Perpetual Chemical and Compressed Gas Inventory Instructions).

Compressed gas cylinders are considered "in-use" when connected to gas delivery systems or equipment through a regulator or manifold, or as a single cylinder, which serves as the reserve gas cylinder for that system. The definition of "in use" also applies to a single cylinder readily available which cannot be continuously connected to a regulator (e.g. reagent gases). Any compressed gas cylinder not connected to equipment must have the regulator removed and the valve protection device in place.

Compressed gas cylinders must be secured in an upright position by a holder, stand or device specifically designed to secure a cylinder to a wall or fixed object (Figure 4). Securing each cylinder individually is recommended for cylinders in use. The strap or chain must secure the cylinder above its centre of gravity (~2/3 between the shoulder and the midpoint - see Figure 5). Compressed gas cylinders must not be secured within 1m of any exit or within a corridor providing access to exits. A cylinder cart is for relocation only and is not considered securement of a cylinder.

Figure 4. Examples of compressed gas cylinder rack (left), wall bracket (middle), and bench bracket (right) to safely secure compressed gas cylinder.[4]

[4] Air Liquide US.

Figure 5. Example of properly secured compressed gas cylinders (left) and an example of unsafe storage of compressed gas cylinders (right).[5]

Compressed gas cylinders are to be located in a dry, well-ventilated area, protected from mechanical damage and not exposed to temperatures exceeding 52˚C or placed near an open flame. Cylinder integrity is negatively impacted by corrosion caused by moisture and pressure changes resulting from exposure to heat. Some cylinders also have a pressure relief device that will release at elevated temperatures.

Certain gases require special storage provisions (e.g. ventilated gas cabinets or exhausted enclosures) due to their hazard ranking and/or the overall quantities kept in laboratories. Any toxic, pyrophoric or corrosive compressed gas cylinder larger than lecture bottle size must be kept in a certified ventilated gas cabinet when used in laboratories regardless of size, without exception. Refer to *Special Provisions for Compressed Gas Usage* section below for additional details.

Lecture bottles (small cylinders approximately 2 inch x 12 inch, Figure 6) of any gas regardless of hazard classification must be used in chemical fume hoods or other continuously ventilated hood or enclosure, and properly secured by a clamp or lecture bottle stand (Figure 6). Researchers are encouraged to consider alternatives to lecture bottles whenever possible, as they can be costly to dispose of and, in some cases, are not accepted by Hazardous Materials Services due to Transportation of Dangerous Goods constraints. Connect with supplier for options on small refillable cylinders.

[5] The Elm - University of Maryland, Baltimore, EHS' quick guide

Figure 6. Example of a lecture bottle and lecture bottle support stands.[6]

The contents of compressed gas cylinders must be clearly labelled (Figure 7), and labelling is a legislated responsibility of the supplier. If a gas cylinder is not properly labelled, return to the supplier immediately. Colour coding is not an accurate or acceptable indicator of contents. Similarly, when gases are being supplied through a manifold or piped system, each point of use must be clearly identified. At a minimum, markings shall be provided at each control valve, wall, floor or ceiling penetration, at each change of direction, and every 6 m of piping. Markings shall include the name of gas and direction of flow arrow.

Figure 7. Examples of proper labelling of a compressed gas cylinder.[7]

The main compressed gas cylinder valve must be closed as soon as gas supply is no longer necessary. Close via the main cylinder valve (Figure 3), not the regulator outlet valve.

[6] Sigma Aldrich
[7] Daily Med.

Compressed gas cylinders must not be completely emptied: leave ~25psi within the cylinder to prevent backflow and the introduction of contaminants. Promptly remove regulators from emptied cylinders and label as empty. Remove empty cylinders from the lab after use and return to centralized distribution area. Follow the guidelines and requirements as described in *Movement of Cylinders* section.

Segregation of Gases

Some types of gases are incompatible based on their hazard classification and require segregation (Table 2). Those combinations that are marked as *Incompatible* must be kept separate and wherever possible, in separate fire compartments.

The distance can be reduced to 1.5 m if one of the gases is kept in an approved ventilated gas cabinet. No limitations apply when both gases of a different category are enclosed in cabinets. Gases of the same hazard category can be stored together in the same ventilated gas cabinet up to a maximum of three compatible gases per cabinet.

Table 2. Segregation requirements for compressed gases based on type/hazard classification.

	Inert	**Flammable**	**Oxidizing**	**Corrosive**	**Toxic**	**Pyrophoric**
Inert		Compatible	Compatible	Compatible	Compatible	Compatible
Flammable	Compatible		Incompatible	Incompatible	Incompatible	1 m apart
Oxidizing	Compatible	Incompatible		Incompatible	1 m apart	Incompatible
Corrosive	Compatible	Incompatible	Incompatible		1 m apart	1 m apart
Toxic	Compatible	Incompatible	1 m apart	1 m apart		1 m apart
Pyrophoric	Compatible	1 m apart	Incompatible	1 m apart	1 m apart	

STORAGE IN LABORATORIES AND OTHER AREAS

Laboratories are not to be used to store compressed gas cylinders; the intent is to limit the quantities of hazardous materials products to those required for normal operations. Only cylinders that meet the definition of “in use” (refer to *Cylinder in Use* section for definition of “in use”) shall be kept withing the laboratory. Cylinders must be adequately secured with the reserve cylinder having the valve protection device remaining in place. Any cylinders kept on site must be inventoried in Chematix (see Perpetual Chemical and Compressed Gas Inventory Instructions).

Designated compressed gas cylinder storage facilities, such as central distribution centres or stores on campus, are designed and built to meet specific code requirements for storage of larger quantities of compressed gases.

SPECIAL PROVISIONS FOR COMPRESSED GAS USAGE

As part of the hazard identification and control process, some types of compressed gases may require additional controls or have restrictions in use. For a list of required and recommended controls pertaining to compressed gas usage, refer to UCalgary Fixed Gas Detection (FGD) Determination Process and FGD Controls Table.

Ventilated Gas Cabinets

Based on their hazard type/classification, work with certain gases require a certified ventilated gas cabinet for cylinder sizes exceeding lecture bottle size (Figure 8). These include:

- Corrosive gases
- Toxic gases
- Pyrophoric gases

A maximum of up to three cylinders of the same hazard type/class can be kept in one ventilated gas cabinet.

Contact Campus Engineering if installation of a ventilated gas cabinet is required for laboratory operations with these types of gases. If gas falls within more than one hazard classification, the more stringent requirements must be followed, e.g. if a gas is classified as flammable and toxic, the toxic gas requirements apply. Refer to Appendix I for Hazard classification of commonly used gases.

Figure 8. Examples of ventilated gas cabinets.[8]

[8] Air Liquide Design and Safety Handbook, 2013.

Lecture Bottles

When not in use, lecture bottles must be stored in a continuously ventilated hood or enclosure in an upright position and segregation guidelines must be applied. The overall number of lecture bottle cylinders in a laboratory is limited to 25 bottles.

Liquefied Petroleum Gases (LPGs)

As with other compressed gases, LPG cylinders must not be stored near exits or areas leading to an exit. LPG cylinders must be kept upright, cool, dry and protected from damage. LPG cylinders are not to be stored inside a flammable cabinet as any escaping gas, which is heavier than air, could settle in the bottom of the enclosure and create a hazard. Additionally, LPG cylinders must be stored a minimum of 6 m from flammable liquids or 3 m, if separated by an enclosure. LPG cylinders >1 lb are not permitted. LPG cylinders up to 1 lb are permitted to a maximum of 20 small volume containers (Figure 9).

Figure 9. Example of small volume LPG cylinders.[9]

DISPOSAL GUIDELINES

Most compressed gas cylinders, including emptied cylinders or those with any unused gas, can be returned to the supplier for refilling. Empty cylinders must be identified as empty with tape or other method of labelling (e.g. marked with MT as abbreviation for empty). Place valve protection device, if applicable, and return cylinder to a storage location for pickup by supplier. Follow the guidelines and requirements as described in *Movement of Cylinders* section.

Lecture bottles, small gas containers (e.g. LPG), and aerosol cans are non-refillable and require disposal as chemical waste when completely empty (i.e., at atmospheric pressure). Refer to the Hazardous Materials Disposal Manual for instructions.

Note: Charges may apply for the disposal of non-returnable gas cylinders, and the cost may be substantial. Contact Hazardous Materials Services for details prior to purchasing.

[9] Canadian Tire.

EMERGENCY PLANNING & RESPONSE

Consider limiting some compressed gas cylinder operation to working hours only and/or to not left unattended. Refer to UCalgary Unattended Operations, After Hours Operation and Working Alone Policies and Guidelines.

Gas Leak

In the event of a leak, attempt to shut off gas supply by closing the cylinder or regulator outlet valve.

If leak persists or gas release occurs at a leaking cylinder, and the leak does *not* cause a dangerous (e.g. explosive, flammable, caustic or asphyxiating) atmosphere:

- Move leaking gas cylinder to a well-ventilated area of the lab, only if safe to do so and lab personnel are comfortable in doing so.
- Set nearby fume hoods to emergency purge if possible.
- Remove sources of ignition.
- Secure area and post appropriate warning signs.
- Inform Supervisor and contact gas supplier for assistance.

If leaking gas *does* cause a dangerous (e.g. explosive, flammable, caustic or asphyxiating) atmosphere:

- Remove sources of ignition, if possible, and evacuate area immediately.
- Secure area and post appropriate warning signs if safe to do so.
- Inform Campus Security at 403-220-5333 with information on location, type of gas and associated dangers, and inform them that **additional ventilation** of location is required.
- Inform Supervisor and contact gas supplier for assistance.

Gas Release

In the event of a rapid gas release, evacuate the area immediately and activate the fire alarm to evacuate the building. Inform Campus Security at 403-220-5333 with information on location, type of gas and associated dangers, and inform them that **additional ventilation** of location is required.

First Aid

- In case of exposure to gas, obtain first aid in accordance with the SDS.
- Call 911 if in critical, life threatening condition. Contact Campus Security at 403-220-5333, if additional medical attention (non-life threatening condition) is required.

Follow the UCalgary Online Accident Reporting System (OARS) instructions on the EHS website to submit a gas leak or gas release incident through OARS.

RELATED DOCUMENTS

UCalgary Laboratory Safety Program
UCalgary Movement of Hazardous Materials Within Buildings Guidelines
UCalgary Chematix Perpetual Chemical and Compressed Gas Inventory Instructions
UCalgary Hazardous Materials Disposal Manual
UCalgary Occupational Health & Safety Policy
UCalgary Fixed Gas Detection (FGD) System Standard
UCalgary FGD Determination Process for Compressed Gases, Cryogenic Liquids, Other
UCalgary FDG Controls Table for Compressed Gases, Cryogenic Liquids, Other
UCalgary Online Accident Reporting System (OARS) instructions

REFERENCES

National Fire Code – Alberta Edition (2019)
National Building Code – Alberta Edition (2019)
NPFA 45 – Standard on Fire Protection for Laboratories Using Chemicals (2019)
NFPA 55 – Compressed Gases and Cryogenic Fluids Code (2020)
NFPA 58 – Liquefied Petroleum Gas Code (2020)
NFPA 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response (2022)
Air Liquide – Design and Safety Handbook for Specialty Gas Delivery Systems (2013)
Canadian Centre for Occupational Health and Safety
Hazardous Products Act and Regulations
WHMIS 1988/2015
Transportation of Dangerous Goods (TDG) Legislation

APPENDIX I. HAZARD CLASSIFICATION OF COMMONLY USED GASES

Table 3 provides information on the main hazards of commonly used gases but is by no means an exhaustive list. Always refer to the SDS for additional information on hazards and handling of gas in use. Consult EHS if still unsure about the properties of any gas prior to use.

Table 3. Hazard classifications of commonly used compressed gases.

	CAS	Flammable (X) Pyrophoric (P) Oxidizer (Ox)	Toxic (X)	Corrosive (X)
Acetylene	74-86-2	X	-	-
Ammonia	7664-41-7	X	X	X
Arsine	7784-42-1	X	X	-
Boron trichloride	10294-34-5	-	X	X
Boron trifluoride	7637-07-2	-	X	X
1,3-Butadiene	106-99-0	X	-	-
n-Butane	106-97-8	X	-	-
Iso-Butane	75-28-5	X	-	-
1-Butene	106-98-9	X	-	-
2-Butene	590-18-1	X	-	-
Carbon monoxide	630-08-0	X	X	-
Carbonyl chloride (Phosgene)	75-44-5	-	X	-
Carbonyl fluoride	353-50-4	-	X	X
Carbonyl sulfide	463-58-1	X	X	-
Chlorine	7782-50-5	-	X	X
Cyanogen	460-19-5	X	X	-
Cyanogen chloride	506-77-4	-	X	-
Cyclopropane	75-19-4	X	-	-
Deuterium	7782-39-0	X	-	-
Diborane	19287-45-7	P	X	-
1,1-Difluoroethane	75-37-6	X	-	-
Dimethylamine	124-40-3	X	X	X
Ethane	74-84-0	X	-	-
Ethylamine	75-04-7	X	X	X
Ethylene	74-85-1	X	-	-
Ethylene oxide	75-21-8	X	X	X
Fluorine	7782-41-4	Ox	X	X
Germanium hydride	7782-65-2	X	X	-
Hexafluoroacetone	684-16-2	-	X	X
Hydrogen (dihydrogen)	1333-74-0	X	-	-
Hydrogen bromide	10035-10-6	-	X	X
Hydrogen chloride	7647-01-0	-	X	X
Hydrogen cyanide	74-90-8	X	X	-
Hydrogen fluoride	7664-39-3	-	X	X
Hydrogen selenide	7783-07-5	X	X	X
Hydrogen sulfide	7783-06-4	X	X	-

Table 3. Continued. Hazard classifications of commonly used compressed gases.

	CAS	Flammable (X) Pyrophoric (P) Oxidizer (Ox)	Toxic (X)	Corrosive (X)
Methane	74-82-8	X	-	-
Methanethiol (Methyl mercaptan)	74-93-1	X	X	-
Methylacetylene (Propyne)	74-99-7	X	-	-
Methylamine	74-89-5	X	X	X
Methylbromide	74-83-9	X	X	-
Methylchloride	74-87-3	X	X	-
Methyl fluoride	593-53-3	X	-	-
Natural Gas	-	X	-	-
Nitric Oxide	10102-43-9	Ox	X	X
Nitrogen dioxide	10102-44-0	Ox	X	X
Nitrogen trifluoride	7783-54-2	Ox	-	-
Nitrosyl chloride	2696-92-6	Ox	X	X
Oxygen	7782-44-7	Ox	-	-
Oxygen difluoride	7783-41-7	Ox	X	X
Ozone	10028-15-6	Ox	X	-
Phosgene	75-44-5	-	X	X
Phosphine	7803-51-2	P	X	-
Propane	74-98-6	X	-	-
Propylene	115-07-1	X	-	-
Selenium hexafluoride	7783-79-1	-	X	X
Silane	7803-62-5	P	-	-
Silicon tetrafluoride	7783-61-1	-	X	X
Stibine	7803-52-3	X	X	-
Sulfur dioxide	7446-09-5	-	X	X
Sulfur tetrafluoride	7783-60-0	-	X	X
Sulfuryl fluoride	2699-79-8	-	X	X
Tetrafluoroethylene	116-14-3	X	-	-
Tungsten hexafluoride	7783-82-6	-	X	X
Trimethylamine	75-50-3	X	X	X

APPENDIX II. COMPRESSED GAS CYLINDER USE FLOWCHART

This flowchart provides safety considerations for the use of compressed gas cylinders in laboratories based on hazard classifications and hazard ranking. Always consult the SDS for information on hazard classification, handling, and incompatibilities to ensure proper use and separation.

To use the flowchart, follow the arrows by starting on the top left (toxic). For gases with more than one hazard classification, priority is given to whichever occurs highest on the chart. Safety considerations always overrule those further down in the flowchart. For example, if a compressed is toxic and flammable, the safety considerations for toxic should be followed.

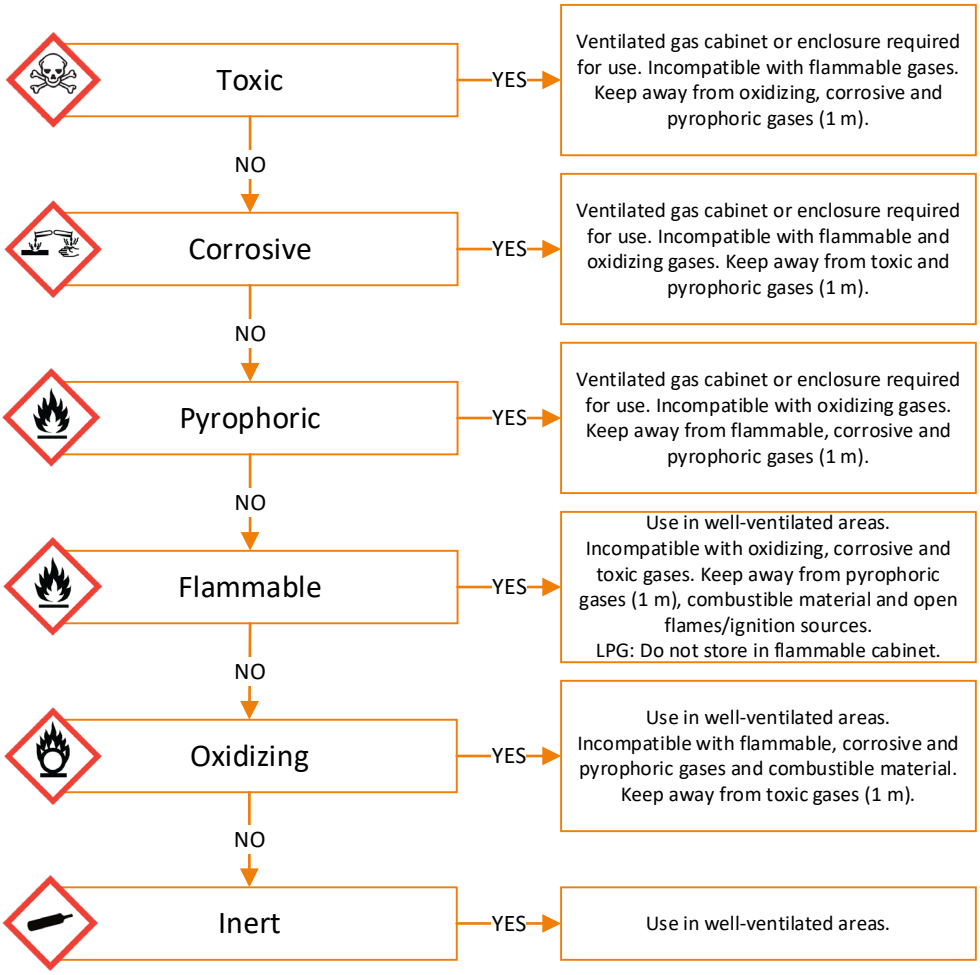


Figure 10. Compressed Gas Cylinder flowchart with safety considerations for use in laboratories.

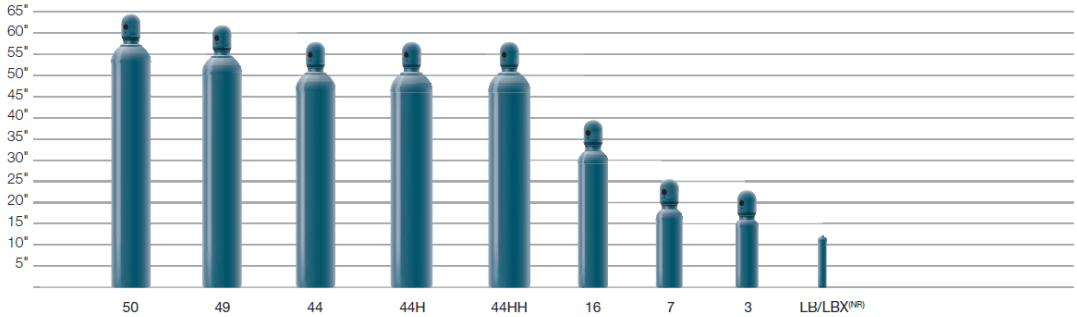
APPENDIX III. CYLINDER SIZING CHART

Table 4 and Figure 11 list details on common compressed gas cylinder sizes. For additional information, contact the supplier directly.

Note: The internal water volume is used as the container size when adding compressed gas cylinders to the Chematix inventory (see UCalgary Perpetual Chemical and Compressed Gas Inventory Instructions).

Table 4. Service pressure, measurements, and internal water volumes of common compressed gas cylinder sizes.

Cylinder code (AirLiquide/Praxair)	Service pressure / psig	Approx. capacity / ft3	Outer diameter / inch	Height / inch	Internal water volume / L (ft3)
50	2900	335	9	58.2	50 (1.8)
49/T(UT)	2400	277	9.25	55	49 (1.7)
44/4K	2265	232	9	51	44 (1.6)
44H/3K	3500	338	10	51	42 (1.5)
44HH/6K	6000	433	10	51	40 (1.4)
16/Q(UG)	2015	76	7	32.5	16 (0.56)
7/G	2015	33	6.25	18.5	7 (0.25)
3/L4	2015	14	4.25	16.75	3 (0.11)
LB	1800	2	2	12	0.4 (0.015)



Cylinder Comparison Chart

Air Liquide	Scott	Airgas	Linde	Matheson	Praxair
49	K	300	049 (T)	1L	T/UT
44	A	200	044 (K)	1A	K/UK
44H	–	–	–	1H	3K
44HH	–	3HP	485	1U	6K
16	B	80	016 (Q)	2	Q/UQ
7	C	35	007 (G)	3	G/UG
3	–	–	3	4	F
LB	LB	LB	LBR (LB)	LB	LB/RB
LBX	–	LX	–	7X	EB

Figure 11. Sizing chart for common compressed gas cylinder sizes.[10]

[10] Air Liquide Design and Safety Handbook, 2013.

APPENDIX IV. REGULATOR CGA CONNECTIONS GUIDE

Table 5 lists the CGA (Compressed Gas Association) connections for commonly used gases. For further information on gases not listed or gas mixtures contact the supplier.

Table 5. CGA (Compressed Gas Association) connections for commonly used gases.

Gas	CGA Connection	Washer required
Acetylene	410/510	-
Air	590	-
Ammonia	240, 660, 705	X (660, 705)
Argon	580	-
Butanes	510	-
Butenes	510	-
Carbon dioxide	320	X
Carbon monoxide	350	-
Deuterium	350	-
Helium	580	-
Hydrogen	350	-
Hydrogen chloride	330	X
Hydrogen sulphide	330	X
Methane	350	-
Natural Gas	350	-
Nitrogen	580	-
Nitrous oxide	326	-
Oxygen	540	-
Propane	510	-
Lecture bottle	170/180	X (170, 180)

Authorization

Only individuals oriented to the Compressed Gas Cylinder Standard, the Compressed Gas Regulator Installation Standard Operating Procedure and trained by experienced laboratory personnel competent in performing the task are permitted to perform this task. Individuals must be knowledgeable of the gas being handled and informed of the associated hazards as outlined on the Safety Data Sheet (SDS) and the Hazard Assessment and Control Form (HACF).

Hazards associated with Regulator Installation

- Contents under pressure, rapid uncontrolled release may cause injury.
- Further hazards specific to gas properties, refer to SDS.

Personal protective equipment (PPE)

- Lab coat and eye protection at minimum and as specified in the current HACF.
- Further PPE may be required dependent on gas properties, refer to SDS.

Before you start work

- Refer to the HACF and SDS for the hazards of gas being handled, review the Compressed Gas Cylinder Standard.
- Ensure the cylinder is clearly labelled and secured in an upright position by a holder, stand or device specifically designed to secure a cylinder to a wall or fixed object.
- Ensure you know the desired delivery pressure to your system, apparatus or equipment.
- Always use a compressed cylinder with a two-stage pressure-reducing regulator with a high-pressure and low-pressure gauge to monitor cylinder and delivery pressure, respectively (Figure 12).
- Ensure that the regulator material is compatible with the gas in use.
- Ensure that the cylinder and regulator have the appropriate CGA (Compressed Gas Association) connections for the gas or gas mixture in use (Refer to Appendix III for commonly used gases in Compressed Gas Cylinder Standard or contact supplier). Never use an adaptor between a cylinder and a pressure-reducing regulator. Never replace the CGA connection with one for a different gas.
- Some regulators require a washer between the cylinder outlet and regulator to seal properly (See Appendix IV. Regulator CGA Connections Guide in Compressed Gas Cylinder Standard). Check that the washer is in place and intact; replace with a new washer if required.
- Label each new gas regulator with its intended gas use. Regulators that have been used for oxidizing gases must not be used for a different gas. Cross-contamination of internal parts (especially with grease or oil) could cause a rapid oxidation and fire. It is strongly recommended that regulators are dedicated to one gas service/equipment.

- Avoid using any aids such as lubricants, Teflon tape or other sealing material (except washer where applicable). Cylinder connections are designed to connect without the use of these. Small particles can get into the regulator with the potential to cause a leak, malfunction and/or reading error.

Step by Step Instructions

1) Put on PPE.
2) Pre-position cylinder so that the regulator will be protected once installed.
3) Remove the cylinder valve protection device.

Note: Some cylinders have a permanent valve guard (Figure 12, right) in place for valve protection instead of a removable valve cap. A cylinder cap hook (Figure 13) can be used to loosen tight cylinder caps. Do not insert a wrench or other device through the cap to loosen as this can damage the valve inside or accidently open the valve.

4) Remove any loose debris from the threads and regulator connection port. Inspect regulator and cylinder components and threads for damage. Do not use if damaged.
5) Turn the regulator's pressure adjustment knob out (counter clockwise) until it feels loose.
6) Ensure the regulator outlet valve is in the closed position (turn clockwise)
7) Check that the washer is in place and intact; replace with a new washer if required.
8) Thread regulator connection nut onto cylinder by hand until snug and then tighten the connection nut to moderate torque with a non-adjustable jaw wrench of the right size.

Note: Do not over-tighten the nut – Excessive torque can damage the thread. Adjustable wrenches, if not a proper fit, may damage regulator connection nuts. Pliers must never be used to tighten the nut. Nuts with a notch have a left-hand thread that is turned counter clockwise to tighten (Figure 14, left), and nuts without a notch have a right-hand thread that is turned clockwise to tighten (Figure 14, right). Avoid using Teflon tape or any other sealing aids on threads with the exemption of applicable washers.

9) Stand at an angle to the gauge face with the outlet facing away. Observe the high-pressure gauge but do not look directly at the gauge as sudden pressurization can cause the gauge face to shatter.
10) Open the cylinder valve *slowly* – turn hand wheel or lift lever valve, as applicable (Figure 12) – until the cylinder pressure gauge needle indicates the cylinder pressure. For hand wheel-type valves, fully open the cylinder valve, then close it one-quarter turn. For lever-type valves, fully lift lever.

Note: It is not necessary or desirable to leave the cylinder valve hand wheel in the fully open position. By opening it only part way shutdown is quicker in the case of an emergency. With older models of oxygen cylinders, if you detect leaking, you may have to open the cylinder all the way to back-seat the cylinder valve.

For acetylene cylinder: Use the following practice to allow quick closing of the cylinder valve in the event of an emergency:

- Open cylinder valve no more than one and one-half turns
- Leave the wrench on the valve spindle when the cylinder is in use, if the cylinder has a T-wrench instead of a hand wheel-type cylinder valve.

11) If a hissing sound is heard from the regulator, immediately close the cylinder valve. Remove regulator and have it serviced.

12) Test the cylinder/regulator connection with leak detection solution. Refer to Leak Testing SOP for details and step-by-step instructions.

Note: Never pressurize above the maximum delivery range of the regulator or the system in use. Never use a regulator with the pressure adjustment knob fully screwed in. If higher pressures or flow rates are required, select a suitable regulator.

13) Open the regulator outlet valve and readjust the delivery pressure at the pressure adjustment knob if required.

Regulator Use

1) Monitor the delivery pressure regularly and make adjustments as necessary. Do not use the regulator outlet valve to control delivery pressure.

2) Do not let the cylinder pressure drop below 25psi to reduce potential for backflow and contamination.

Regulator Disconnecting

1) With the regulator outlet valve open, close the cylinder valve.

2) Monitor the pressure gauges until they drop to zero. When both gauges read zero, unscrew the pressure adjustment knob (counter clockwise).

3) Disconnect the delivery hose from equipment and disconnect the regulator from the cylinder using a jaw wrench of the correct size.

4) Place the cylinder valve protection device (cap only, not required with valve guard in place).

Maintenance

- For regulators that require washers, always check that the washer is in place and intact; replace with a new washer if required.
- Unscrew the pressure adjustment knob (counter clockwise) when regulator is not in use. This releases pressure from the diaphragm.
- Check regulator and cylinder components for damage. Contact supplier for damaged cylinders. Submit damaged regulators for servicing.

- All regulator servicing is to be performed only by an authorized service centre. Contact supplier for regulator servicing and recommended intervals.

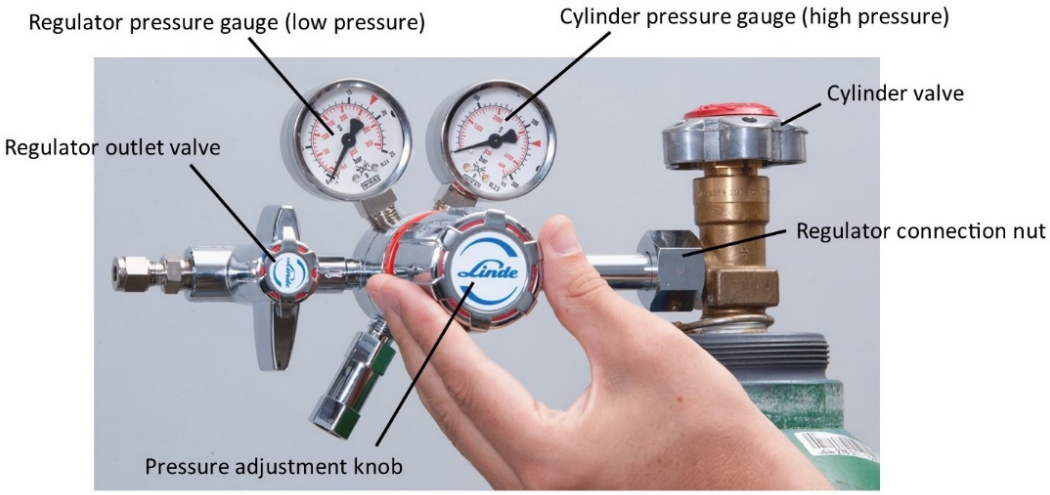


Figure 12. Two-stage regulator connected to a compressed gas cylinder with a hand wheel-type cylinder valve.[11]

Figure 13. Example of a cylinder cap hook and how to use it to remove the valve cap.[12]

[11] Linde Specialty Gases.
[12] Sigma Aldrich; https://www.gasequipmentcatalog.net/product/119

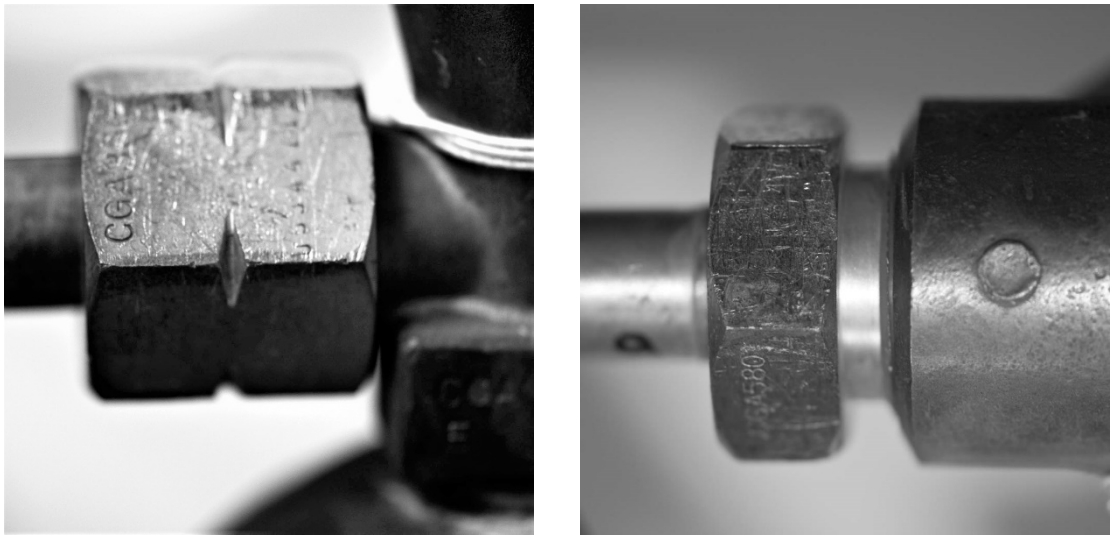


Figure 14. Types of regulator connection nuts: Left hand thread (left) recognizable by a notch on the thread that is turned counter clockwise to tighten, and right hand thread without notch that is turned clockwise to tighten (right).

Authorization

Only individuals oriented to the Compressed Gas Cylinder Standard and the Leak Testing Standard Operating Procedure and trained by experienced laboratory personnel competent in performing the task are permitted to perform this task. Individuals must be knowledgeable of the gas being handled and informed of the associated hazards as outlined on the Safety Data Sheet (SDS) and the Hazard Assessment and Control Form (HACF).

Hazards associated with Regulator Installation

- Contents under pressure, rapid uncontrolled release may cause injury.
- Further hazards specific to gas properties, refer to SDS.

Personal protective equipment (PPE)

- Lab coat and eye protection at minimum and as specified in the current HACF.
- Further PPE may be required dependent on gas properties and leak testing solution used, refer to SDS.

Before you start work

- Connections between a regulator and compressed gas cylinder must be checked for leaks after each installation and compressed gas manifold systems/equipment must be checked for leaks upon first installation and whenever manipulations are made post installation (at minimum).
- Refer to Compressed Gas Regulator Installation SOP for step-by-step instructions on how to connect a regulator to a compressed gas cylinder.
- When using toxic or corrosive gases, leak tests must be performed on the system at working pressure with an inert gas first. The system must be purged with an inert gas whenever major changes have to be made after the initial set-up.
- Soap water or commercially available leak detection solutions such as Snoop® are most commonly used for leak testing. Never use a flame to conduct a leak test.
- Leak detection solutions must be compatible with the gas and materials used (e.g. must be non-corrosive).
- Soap water and some leak detection solutions (oil- or fatty acid-based) are incompatible with oxygen/oxidizers, their residues could cause spontaneous ignition. Snoop® does not leave any residues and fulfils requirements for testing of systems using oxygen/oxidizers.
- Refer to operation manual of equipment or check with manufacturer for recommended leak testing method and intervals. Some leak detection solutions may be incompatible with certain parts/materials of a system; a leak test instrument (e.g. portable Helium leak detector) might be required instead.
- Never manipulate a system while under pressure. Always shut off gas supply and depressurize to tighten connections.

Step by Step Instructions

1) Put on PPE.
2) Pressurize the system to desired working pressure.
3) Apply leak detection solution to all connections (e.g. cylinder valve, regulator connections, inlets/outlets at equipment, if possible).
4) Bubble formation indicates a leak at a connection.
5) In case of a leak: shut off gas supply and depressurize the system.

Note: If a toxic or corrosive gas is being used, purge the lines and equipment with an inert gas before proceeding. Refer to equipment manual for purging instructions.

6) Inspect and attempt to tighten the connection using the appropriate tools.
7) Re-pressure the system and re-test the connections for leaks.
8) If leak has been fixed, the system is ready to use.
9) If leak persists, check for damage to the face of the fitting, debris in the cylinder valve connection or a missing/damaged washer.
10) Test the connection using a different compatible regulator to determine if the leak originates at the cylinder or at the regulator.
11) If the cylinder is leaking, do not use the system. Shut off the gas supply and inform supervisor to determine next steps.
12) After testing, dry areas by wiping with a clean cloth.

Maintenance

- Keep connections clean and inspect upon each installation or major modification.