Compressed Gas Cylinder Safe Handling, Use and Storage

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2022

UBC - Okanagan Campus

Health, Safety & Environment

Contents

1 Purpose

The guide is intended to provide information on the safe handling, use and storage of compressed gases at the University of British Columbia on the Okanagan Campus.

2 Applicability

This guide is applicable to all faculty, staff, students, and visitors at the university who will be using and handling cylinders of compressed gases.

3 Definitions

Compressed Gas: Any contained mixture or material with either an absolute pressure exceeding 275.8 kPa at 21ºC or an absolute pressure exceeding 717 kPa at 54ºC, or both, or any liquid having an absolute vapour pressure exceeding 275.8 kPa at 37.8ºC.

Flashback Arrestor (or Flame Arrestor): A device commonly used with oxy-fuel welding or cutting activities to prevent the flame from burning back into the hose or gas cylinders thereby preventing damage to equipment. The arrestor is placed between the torch (or flame source) and the hoses, although there are arrestors that attach directly to the gas regulator.

Lecture Bottle: A small compressed gas cylinder that is typically 2-3 inches (5-8 cm) in diameter and 12-18 inches (30-45 cm) in length. These smaller cylinders are used for holding calibration gases or in applications where large quantities of gases are not required. Use of lecture bottles is strongly discouraged.

LEL – Lower Explosive Limit: The lowest concentration of a gas, in air, that will burn or explode when exposed to an ignition source.

Liquefied Gas: Are gases which can become liquids at normal temperatures when they are inside cylinders under pressure. They exist inside the cylinder in a liquid-vapour balance or equilibrium. Initially the cylinder is almost full of liquid, and gas fills the space above the liquid. As gas is removed from the cylinder, enough liquid evaporates to replace it, keeping the pressure in the cylinder constant. Anhydrous ammonia, chlorine, propane, nitrous oxide and carbon dioxide are examples of liquefied gases.

SDS: Safety Data Sheets.

Odour Threshold: The odour threshold is the lowest concentration of a chemical in air that is detectable by the human sense of smell. Odour thresholds should only be regarded as estimates as the ability to detect odours in a work environment varies from person to person.

Olfactory Fatigue: Olfactory fatigue, also known as odour fatigue or olfactory adaptation, is the temporary, normal inability to distinguish a particular odour after a prolonged exposure to that airborne compound.

PPE: Personal protective equipment.

PPM: Parts per million, a unit of concentration.

PSI: Pounds per square inch, a unit of pressure.

PSIG: Pound force per square inch gauge, a unit of pressure relative to the surrounding atmosphere.

Supervisor: A person who is authorized by the university to oversee or direct the work of employees and students. At the lab level, this is often the Principal Investigator. Although the university recognizes the ultimate responsibility of performing work in a safe manner lies with the individual, supervisors have additional responsibilities, which arise from their role as persons responsible for providing competent supervision and managing the workplace under their authority.

TC/DOT: Transport Canada/Department of Transport.

UEL – Upper Explosive Limit: The maximum concentration of a gas, in air, that will burn or explode when exposed to an ignition source.

4 Responsibilities

Supervisors are responsible to:

- Ensure staff, students and visitors in their charge receive appropriate training specific to the compressed gases they are handling and using;
- Ensure that compressed gases are used only for their intended purpose and in accordance with defined procedures and rules;
- Ensure that applicable Safety Data Sheets (SDS), Standard Operating Procedures (SOPs) or other relevant literature is made readily available to staff and students;
- Provide staff, students and visitors with appropriate personal protective equipment (PPE);
- Provide appropriate supervision of staff and students;
- Ensure staff, students and visitors adhere to applicable occupational health and safety regulations for the use of compressed gases;
- Investigate reported incidents to determine the cause and to develop appropriate preventative measures to minimize a recurrence; and
- Maintain appropriate records pertaining to the handling and use of compressed gases including an up-to-date inventory, training records, and reported incidents;

Staff, students and visitors are responsible to:

- Adhere to defined procedures and rules, and applicable occupational health and safety regulations for the use of compressed gases;
- Wear and maintain PPE provided;
- Participate in required training;
- Notify their supervisor of identified hazards related to the use of compressed gases; and

- Notify their supervisor of any incident related to the use of compressed gases.

Health, Safety & Environment is responsible to:

- Provide information and advice in health, safety and environmental protection including on the safe use of compressed gases;
- Develop and administer health, safety and environmental programs;
- Provide health and safety training;
- Provide hazardous waste disposal services;
- Assist in the response to reported incidents and spills of hazardous materials; and
- Support regulatory compliance.

5 Training Requirements

Only trained personnel shall use compressed and liquefied gases. In order to handle compressed gases you must have completed:

- Chemical Safety Training through Health, Safety and Environment
- Compressed Gas Safety Course (on-line) through Health, Safety and Environment – under development
- Transportation of Dangerous Goods training if you intend on transporting gases by vehicle

Staff, students and visitors must also receive site-specific training on the particular activities they will be engaged in including known hazards and how to protect themselves from those hazards. Training must also be provided on work procedures, rules and emergency response associated with the work to be performed.

It is the responsibility of the supervisor to maintain appropriate records pertaining to staff, student and visitor training.

To register for a safety course, please visit the HSE webpage at hse.ok.ubc.ca.

6 Hazards Associated with Working with Compressed Gases

There are a number of hazards associated with the handling, use and storage of compressed gases. Following is a summary of known hazards. Some general hazards associated with

Pressure Hazards: All compressed gases are hazardous due to the high pressure inside the cylinder. Damage to the cylinder valve can result in a rapid release of the high-pressure gas propelling the cylinder causing personal injury or death and damage to property.

Fire and Explosion Hazards: Flammable gases such as acetylene, butane and hydrogen can burn or explode under certain conditions. If flammable gases are allowed to accumulate until their concentration is between their defined Lower Explosion Limit (LEL) and Upper Explosion Limit (UEL), an explosion may occur if there is an ignition source present.

Health Hazards: Many gases are toxic and can cause serious health problems dependent upon the specific gas, its concentration, length of exposure, and route of entry. Health symptoms of exposure to gases can be immediate, or delayed.

Chemical Burn Hazards: Some compressed gases are corrosive. They can burn or damage skin on contact, burn the eyes or lungs if inhaled, as well as attack and corrode metals.

Cold Temperature Burns: some compressed gases are very cold when released at room temperature. Skin and eyes can be permanently damaged due to exposure to cold gases.

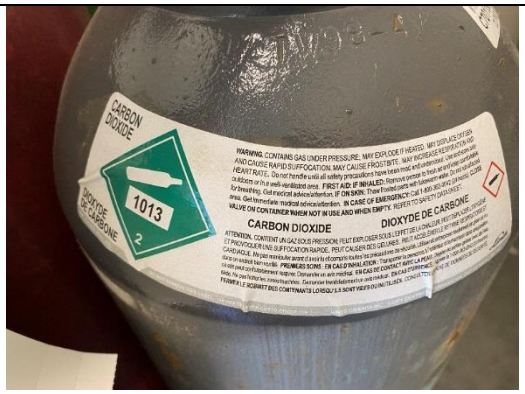
Asphyxiation Hazards: Asphyxiation is the main hazard associated with inert gases such as helium, argon, and nitrogen. If these gases escape undetected into the atmosphere, they can quickly reduce the oxygen levels below concentrations necessary to support consciousness and life.

Physical Hazards: Compressed gas cylinders are large, heavy and awkward to handle. Improper handling, or not properly securing cylinders while in use, can cause cylinders to fall causing injury to workers.

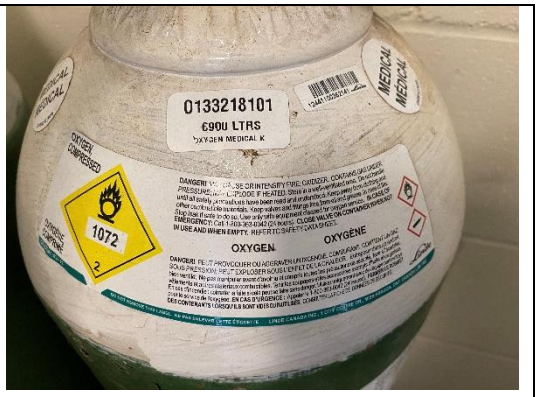
7 General Gas Cylinder Information

Many manufacturers colour code their cylinders of compressed gases. These colour coding systems are not standardized and should not be used to verify the contents in a compressed gas cylinder. Manufacturers are required, by law, to label their cylinders to identify the gases they contain and the label should be used to positively identify the contents of a cylinder. Linde is a common gas supplier on campus.

See Figure 1 for examples of Linde cylinder labels commonly seen on campus. The identification label (c) in Figure 1 is used to identify the account holder / lab / principal investigator responsible for the cylinder. There are two tear off strips at the bottom of the identification label. The first one should be removed when the gas in the cylinder begins being used. The second is removed when the cylinder is empty.



(a)



(b)

(c)

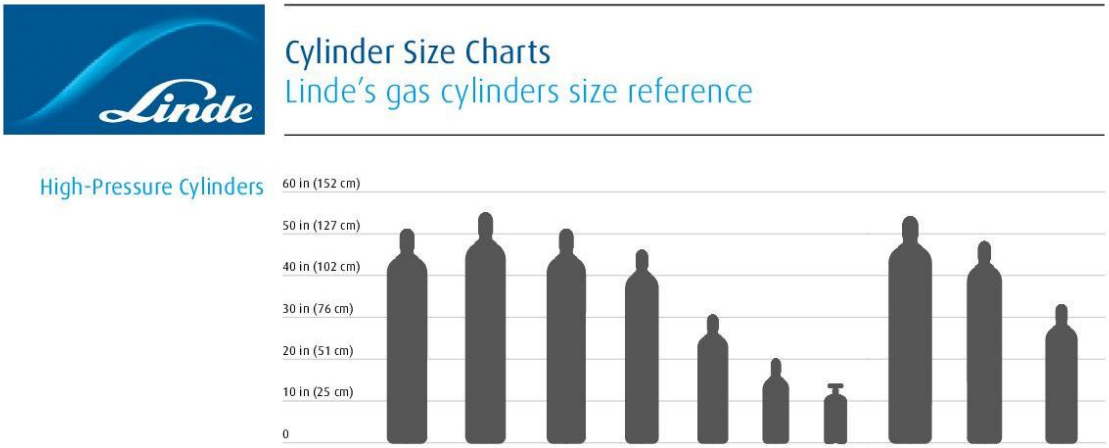
Figure 1. Examples of Linde gas cylinder labels.

(a) Carbon Dioxide -The green diamond indicates that the cylinder is a compressed gas.

(b) Oxygen – The yellow diamond indicates that the gas inside the cylinder is an oxidizer.

(c) Cylinder Identification and status label – This label identifies who ordered the gas and the condition of use. Rip off the "Full" portion of the label when the cylinder is in use. Remove the "In Use" when the cylinder is empty.

Common gas cylinder sizes found on campus are shown in Figure 2. **Examples of compressed gas cylinders. Image from Linde. Cylinder Sizes. https://www.lindedirect.com/about-us/frequently-asked-questions/cylinder-information/what-are-the-different-cylinder-sizes**Figure 2.



	Steel							Aluminum		
	4k	T	K		Q	G	R	AT	AS	AQ
Height	51 in.	55 in.	51 in.	46 in.	31 in.	20 in.	14 in.	54 in.	48 in.	33 in.
Diameter	9.25 in.	9.25 in.	9.0 in.	7.4 in.	7.0 in.	6.0 in.	5.1 in.	10 in.	8 in.	7.3 in.
Average weight	145 lbs.	143 lbs.	133 lbs.	76 lbs.	65 lbs.	29 lbs.	14 lbs.	90 lbs.	48 lbs.	30 lbs.
Water capacity	100 lbs.	108 lbs.	97 lbs.	60 lbs.	32 lbs.	16 lbs.	8.1 lbs.	106 lbs.	65 lbs.	34 lbs.

Dimensions and capacities are approximate and may vary slightly.

Figure 2. Examples of compressed gas cylinders. Image from Linde. Cylinder Sizes. https://www.lindedirect.com/about-us/frequently-asked-questions/cylinder-information/what-are-the-different-cylinder-sizes

8 Compressed Gas Regulators

Gas regulators are used to reduce the high pressure of a compressed gas cylinder to safe and useable pressures. They are designed for use with a specific gas, within prescribed pressure ranges. The main components of a typical gas cylinder and regulator assembly are shown in Figure 3.

Cylinder regulators have a relief device to prevent excessive pressure from developing. High pressure cylinder regulator gauges have a solid-front, safety-back construction. When subject to excessively high pressure, the light-metal safety back will blow off to relieve the pressure.

Always use the proper regulator for the gas in the cylinder as they are designed to provide the correct flow rate for that particular gas. Using the wrong regulator may cause some gases to react with the materials inside the regulator. **For example, materials used in some regulators are not designed for oxygen and could ignite causing a fire or explosion.**

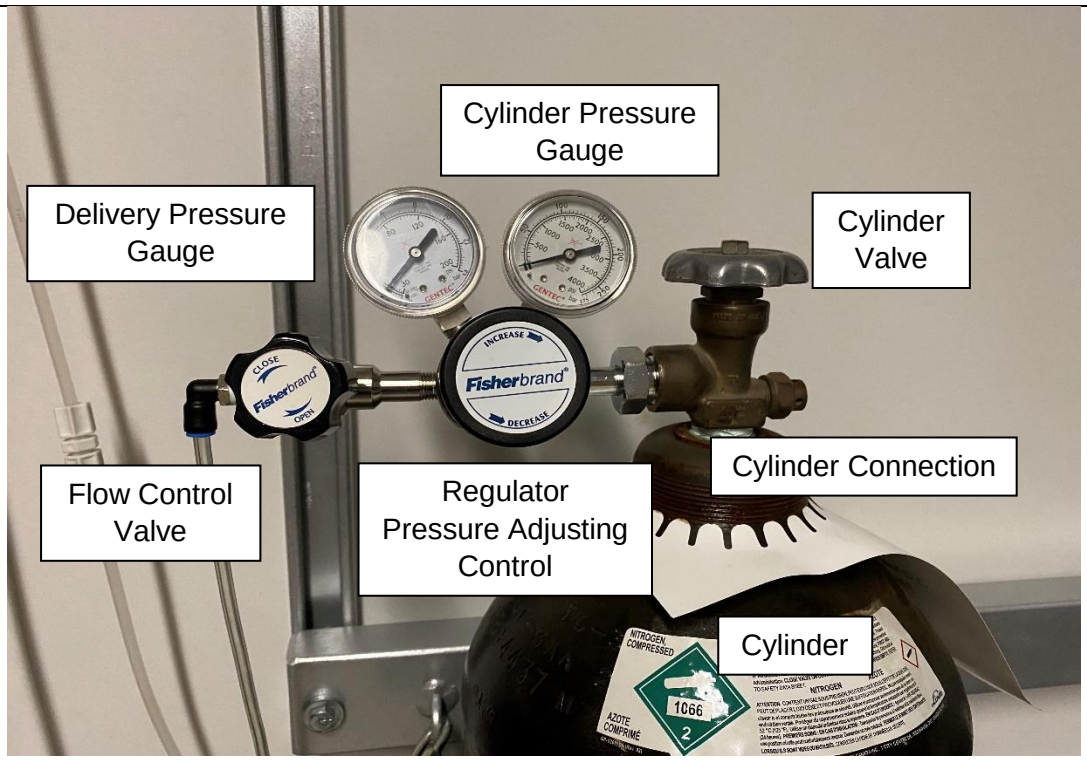


Figure 3. Main components of a compressed gas cylinder and regulator assembly.

Plaques, decals or engraved numbers on the regulator may indicate which gas the regulator is designed for. Cylinder valve connections on regulators are also designed to minimize the chances of using the wrong regulator. Always verify that you have the correct regulator for your application.

There are regulators that are left hand threaded (the connection is tightened by turning the nut counterclockwise). These Compressed Gas Association (CGA) connectors will have an identifying notch in them or a line inscribed around the circumference.

The CGA has developed a system to help prevent using the incorrect regulator on a compressed gas cylinder. Each cylinder and regulator has a connection fitting that is designated by a CGA number. Some common CGA numbers are presented in **Error! Reference source not found.**. An example of a gas cylinder connector with a left hand thread is found in Figure 4.

Table 1. CGA connection numbers for compressed gas cylinder regulators.

Gas	CGA Connection	Gas	CGA Connection
Acetylene	510	Hexafluoroacetone	330
Air (breathing air)	346	Hexafluoropropylene	660
Air (industrial grade)	590	Hydrogen	350
Allene	510	Hydrogen bromide	330
Ammonia	705/240	Hydrogen chloride	330
Argon	580	Hydrogen fluoride	670
Arsine	350	Hydrogen iodide	330
Boron trichloride	660	Hydrogen selenide	350
Boron trifluoride	330	Hydrogen sulfide	330
Bromine pentafluoride	670	Iodine pentafluoride	670
Bromine trifluoride	670	Isobutane	510
Bromotrifluoroethylene	510	Isobutylene	510
1,3-butadiene	510	Krypton	580
Butane	510	Methane	350
Butenes	510	Methylacetylene	510
Carbon dioxide	320	Methylbromide	330
Carbon monoxide	350	3-Methylbutene	510
Carbonyl fluoride	750	Methylchloride	510
Carbonyl sulfide	330	Methyl mercaptan	330
Chlorine	660	Monoethylamine	705
Chlorine trifluoride	670	Monomethylamine	705
Chlorotrifluoroethylene	510	Natural gas	350
Cyanogen	750	Neon	580
Cyanogen chloride	750	Nickel carbonyl	660
Cyclopropane	510	Nitric oxide	660
Deuterium	350	Nitrogen	580
Diborane	350	Nitrogen dioxide	660
1,2-Dibromodifluoromethane	668	Nitrogen trioxide	660
Dimethylamine	705	Nitrosyl chloride	330
Dimethylether	510	Nitrous oxide	326
2,2-Dimethylpropane	510	Oxygen	540
Ethane	350	Perfluoro-2-butene	660
Ethyl acetylene	510	Perfluoropropane	660
Ethyl chloride	510	Phosgene	660
Ethylene	350	Phosphine	350
Ethylene oxide	510	Phosphorous pentafluoride	330
Fluorine	679	Propane	510
Freon 12 (dichlorodifluoromethane)	660	Propylene	510
Freon 13 (chlorotrifluoromethane)	660	Silane	350
Freon 13B1 (bromotrifluoromethane)	660	Silicon tetrafluoride	330
Freon 14 (tetrafluoromethane)	580	Sulfur dioxide	660

Gas	CGA Connection	Gas	CGA Connection
Freon 22 (chlorodifluoromethane)	660	Sulfur hexafluoride	590
Freon 114 (1,2- dichlorotetrafluoroethane)	660	Sulfur tetrafluoride	330
Freon 116 (hexafluoroethane)	660	Sulfuryl fluoride	660
Freon RC318 (octafluorocyclobutane)	660	Tetrafluoroethylene	350
Genetron 21 (dichlorofluoromethane)	660	Trimethylamine	705
Genetron 23 (fluoroform)	660	Vinyl bromide	510
Genetron 115 (monochloropentafluoroethane)	660	Vinyl chloride	510
Genetron 152A (1,1-difluoroethane)	510	Vinyl fluoride	350
Genetron 1132A (1,1-difluoroethylene)	350	Vinyl methylether	510
Germane	350	Xenon	580
Helium	580		

Figure 4. Example gas cylinder connector (Western CGA-590X). Image courtesy of Air Gas. https://www.airgas.com/product/Gas-Equipment/Gas-Equipment-Accessories/Adapters-&-Fittings/p/WES815

9 Safety Handling and Use of Gas Cylinders

9.1 General Safety and Precautions

When using gas cylinders, there are a number of general safety measures that should be adhered to.

- Individuals working with the gas cylinders must be appropriately trained by their supervisor;
- Gas cylinders are only to be used for their intended purpose;
- Ensure equipment is compatible with cylinder pressure and contents (See Section 8 Compressed Gas Regulators);
- Ensure that the proper regulator and fittings are used for the particular gas in the cylinder. The Valve number and CGA number must match;
- Gas cylinders must be firmly affixed to an immovable object at 2/3 height with chains or straps so that it cannot be knocked over in use;
- Wear PPE appropriate for the hazard potential of the material being worked with. At a minimum, wear a lab coat, safety glasses, gloves, long pants and fully enclosed shoes.;
- Refer to the SDS for details on the safe handling of the material Remove any dirt, grit, oil or rust from the valve and fixture – these can cause gas leaks if they get into valve or connection;
- Each time a compressed gas cylinder is used, the cylinder, regulator and connections should be visually inspected for disrepair or damage;
- Bond and ground all flammable compressed cylinders, lines and equipment;
- Keep the cylinder clear of all sparks, flames and heat sources;
- Ensure the cylinder, regulator and associated equipment are properly maintained.
- Remove all pressure from regulators not currently in use;
- Store gases with safety cap on when they are not in use;
- When working with toxic gases the installation of permanent gas detectors (Figure 5) or carrying personal detectors for leak detection is needed. Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained;
- Toxic gases cannot be stored within a building unless they are in a vented enclosure.
- Use a flashback arrestor for flammable and oxidizing gases, it will stop gas flow in the event of a reverse flow or flashback;
- Never open a damaged valve. Contact your supervisor to notify the supplier;
- Do not lubricate valves, fittings or regulator threads; consult the supplier for approved lubricants;
- Never refill a gas cylinder;
- Never use cylinder gas as a source of compressed air;
- Never heat the cylinder to raise the pressure of the gas as this may defeat the safety mechanisms built in by the supplier;
- Never use copper fittings or tubing on acetylene tanks as an explosion may result; and
- Gas cylinders should never become part of an electrical circuit;

The Compressed Gas Safety Association has created a poster that summarizes the basic hazards of compressed gas cylinders. (Appendix A)

Figure 5. Permanent toxic gas detector. Image from RC Sensors https://www.rcsystemsco.com/toxic-and-oxygen-gas-detectors/sensmart-3100-ec

9.2 Receiving Gas Cylinders

Following, are guidelines for safely receiving gas cylinders. You may refuse gas cylinders that do not meet your expectations.

- Read the cylinder label to confirm the gas received is the gas purchased. Never identify the product by the color of the cylinder. Identify gases by their label (Figure 1) and the Safety Data Sheet (SDS);
- Thoroughly inspect the cylinders for any obvious damage such as cuts, gouges, burn marks, and obvious dents. The cylinder surface should be clean;
- Cylinders with neck threads should have a cap in place over the valve. Remove the cap by hand. Never use a screwdriver, crowbar, or other leverage device to remove the cap;
- Check the cylinder valve to be sure it is not bent or damaged. A damaged valve could leak, fail, or not provide a tight connection;
- Ensure the valve is free of dirt and oil, which could cause a gas leak or contaminate the gas. Dirt particles propelled in a high-velocity gas stream could cause a spark, igniting a flammable gas. Oil and grease can react with oxygen and other oxidizers, causing an explosion;
- An SDS for the contents of each cylinder must be provided with the gas cylinder or must already be present in the lab for the gas being received.
- If any cylinder is received with missing or unreadable labels and markings, has visible damage, do not use the cylinder. Contact your supplier and ask for instructions.
- Ensure that the gas is compatible with the materials already present in the room.
    - Flammables and oxidizers may <u>not</u> be stored together (either indoor or outdoor);
    - Toxic gases may not be stored indoors except in a vented enclosure.

Individuals receiving gas cylinders must have completed the following training:

- Current Chemical Safety training (updated within the last 5 years);
- Transportation of Dangerous Goods;
- Gas Safety Training within the lab;
- UBCO Gas Safety Training (under development)
- Lab Specific Training & Orientation.

9.3 Moving Cylinders

9.3.1 Cylinder Preparation

Before moving a cylinder to a storage area, a point of use, or before returning the cylinder to the supplier, ensure the following:

- The outlet valve is fully closed;
- Remove the regulator. Never move a cylinder with the regulator attached as this can increase the risk of damage;
- The outlet valve dust plug or pressure cap is on tight for cylinders equipped with these protection devices;
- The valve protection cap is properly secured in place on cylinders with neck threads. Ensure the pathway is clear prior to moving cylinder. Be aware of flooring grade changes and use an elevator, if available; and

9.3.2 Method of Transportation

When moving compressed gas cylinders:

- Always use a cart or hand truck designed for this purpose (Figure 6). Ensure the cylinder is secured to the cart during transport with a chain or strap.
- Cylinders should not be dragged, rolled or manually carried;
- Never drop cylinders or allow them to strike each other violently;
- Cylinders shall not be lifted by the valve cap;
- Do not drag, slide, or roll the cylinder on its side;
- Magnets, chains or wire rope slings shall not be used for lifting cylinders.
- Steel toed boots are highly recommended when moving gas cylinder.
- Do not remove the valve cap before the cylinder is secured in place.

Figure 6. Example of a cylinder cart. From Just-Rite. https://www.justrite.com/lift-and-load-single-cylinder-hand-

Transportation across campus:

- Plan your route. (Appendix B)
- Transport with a minimum of 2 people. One person pushes the cylinder, while the second clears the route and looks of obstructions.
- Avoid transporting a cart:
    - Across uneven surfaces

- Up / down hills
- Through crowded areas
- During busy times of day

9.3.3 Use of Elevators

Elevators are a confined space with limited ventilation. In case of a sudden release of gas from a cylinder, a person can quickly asphyxiate in an elevator due to lack of oxygen. Cylinders that regularly release pressure (such as low pressure liquid nitrogen or argon Dewars) are particularly dangerous. Cylinders containing compressed air are the lowest risk to transport in elevators.

Guidelines for Elevator Transportation:

- Passengers (other than those involved in the transportation of cylinders) are forbidden in an elevator with a compressed gas cylinder or Dewar. Respectfully ask others to wait for the next available elevator;
- Use freight or secondary elevators where possible;
- It is not advisable to travel in an elevator with a compressed gas cylinder.
- If it is not possible to send the gas cylinder alone in the elevator, only one person should transport with the cylinder.

Best practice for transportation with an elevator:

1. Place a sign on the cylinder indicating that a compressed gas cylinder is in transport and that passengers are forbidden. Include your name and lab number. An example sign is found in Appendix C.
2. Post a lab person at the elevator door on every floor between the start and destination floor.
3. Secure the cylinder into the elevator.
4. Press every button between the start and arrival floor. Once the cylinder passes a given floor, the person stationed at that floor can safely leave the door unattended.
5. The person at the destination floor removes the cylinder and waits for the start floor person to arrive.
6. You can hold open doors using the “door open” button on the elevator.

After moving a cylinder to its point of storage or use, secure the cylinder in place. Use cylinder stands, clamps, chains, or other securing devices. Cylinders should be placed so that the valve handle at the top is easily accessible at all times. Once the gas cylinder is secured in place, the valve cap can be removed.

9.4 Placement and Storage of Compressed Gas Cylinders (CGC)

The following safety measures should be adhered to when storing gas cylinders.

- Only store cylinders in designated areas that are well ventilated, dry, and out of direct sunlight, heat and ignition sources.
- Gas cylinders shall not be stored or allowed to come in contact with heat sources
- Segregate cylinders by hazard class; Oxidizing gases should be at least 6 meters away from fuel gases and combustible materials or separated with an approved fire wall. (NFPA 55). (Appendix

D)

- Toxic gases can only be stored indoors inside a ventilated cabinet.
- All cylinders must be secured in place individually to prevent accidental knock over. Cylinders must be secured in an upright position by a cylinder stand, clamp, chain or cable at a point approximately 2/3 of the height of the cylinder (Figure 7);
- Regularly perform a leak test lines leading from compressed gas cylinders to point of use (See Section 10.4)
- When the cylinder is not in use the valve protection cap shall be in place to protect the valve (see Figure 8).

Figure 7. Compressed gas cylinder strapping

- Do not store cylinders:
    - Near the edges of platforms;
    - In areas where activities that could damage or contaminate the cylinders;
    - Under overhead hoists that can drip oil or grease on cylinders, contaminating them;
    - In high traffic areas;
    - In public hallways; nor
    - Within 5 feet of an emergency exit or primary exit route.
- Clearly mark empty cylinders and store separately from full cylinders. Return empty cylinders to designated storage facilities. Request pick up of empty cylinders from suppliers;

Figure 8. Cylinder cap.

- Put the valve cap on am empty gas cylinders before returning it to the gas storage room or vendor.

9.5 Attaching a Regulator

When attaching a regulator to a cylinder, procedures should be followed in a specific sequence. Refer to the manufacturer's specifications when in doubt. Following, is a general outline of the steps to follow when connecting a regulator to a cylinder.

1. Always wear appropriate PPE such as safety glasses or goggles and gloves. A sudden gust of gas could damage your eyes or skin.
2. Before attaching the regulator, perform a visual inspection of the regulator. Check the condition of the inlet and outlet, look for worn threads and inspect gauges for damage.
3. Check to ensure that your regulator is applicable for the gas being used (See Section 8)
4. Visually inspect the cylinder before each usage to detect for any damage, cracks, corrosion or other defects.

5. Wipe the outlet with a clean, dry, lint free cloth. The threads and mating surfaces of the regulator and hose connections should also be cleaned before the regulator is attached. A connection problem caused by dirty or damaged threads could result in leaks when the cylinder is used. Unwanted reactions may occur when some gases contact dust and other contaminants.
6. Always use a cylinder wrench or other tight fitting wrench to tighten the regulator nut and hose connections. Using an oversized wrench, adjustable wrench, pliers or a pipe wrench may damage the fittings and make it impossible to tighten them properly.
7. Attach the proper regulator to the cylinder of compressed gas. Do not use Teflon TM tape on fittings when the seal is made by metal-to-metal contact.
8. Never use grease or oil on regulator or cylinder valves because these substances may cause an adverse, dangerous reaction within the cylinder gas.
9. Check for leaks using a leak detection solution (such as Snoop) or soapy water. Bubbles will form where a leak is present. All parts of the gas line should tested with extra focus on all connections, joints and corners.

9.6 Opening and Closing Cylinder Valves

Observing a few simple rules when opening and closing valves can prevent damage to valves and equipment and add years of useful service life to the valves. Following, are the key steps for properly opening any cylinder valve:

1. Close the regulator by turning the pressure adjusting screw counterclockwise. (See Figure 3)
2. When opening the main cylinder valve, stand to the side and away from the regulator. Do not stand in front of or behind the pressure gauges when applying pressure to the regulator as old, or defective regulators, have violently fragmed and have caused personal injury. Be cautious.
3. Crack the cylinder valve open slightly at first to verify that the regulator's diaphragm is working. The regulator cylinder pressure gauge should register the cylinder pressure. Continue to open the valve slowly to allow equipment to gradually adjust to full pressure. Never apply excessive force when trying to open valves. Do not attempt to open a corroded valve as it may be impossible to reseal.
4. Stop turning as soon as there is any resistance. Turning the valve handle or stem too far in the open position can jam the stem causing damage and leaks, and potentially preventing later closure. Likewise, over tightening when closing a valve can damage or permanently distort the seat and result in leakage. Never leave a valve part way open, either open it all the way or close it all the way.
5. Slowly adjust the regulator control to the desired pressure on the regulatory delivery gauge.

Cylinders that require a wrench to open the main valve shall have the wrench left in place on the cylinder valve while it is open. Use an appropriately sized wrench.

Close valves on gas cylinders when a system is not in use. Even when empty, air and moisture may diffuse through an open valve, causing contamination and corrosion within the cylinder.

10 Gas Cylinder System Maintenance

10.1 Introduction

Regular inspection and maintenance of regulators is important to ensuring their proper operation and to the safety of individuals working with compressed gases.

10.2 Function Testing of Regulators

It is recommended that regulators be function tested every six months. Following, is a general procedure for function testing regulators.

1. Close the regulator by turning the pressure adjusting screw counterclockwise until fully released.
2. Close the cylinder valve. Ensure that lines leading from the regulator to equipment or apparatus are purged of pressure by opening the appropriate flow control valves.
3. The regulator delivery pressure gauge should drop to a pressure reading of zero. Record the delivery pressure gauge reading. The cylinder pressure gauge will read full pressure. Record the initial high pressure.
4. If the delivery pressure gauge does not read zero when all the pressure is removed, it may be damaged. Send regulators suspected of malfunction to the manufacturer for repair, or replace the regulator.
5. Check the cylinder pressure gauge reading after at least 30 minutes. Record cylinder pressure gauge reading. Any pressure drop will indicate leakage. Send regulators suspected of malfunction to the manufacturer for repair, or replace the regulator.
6. Release the pressure in the regulator by turning the pressure adjusting screw clockwise. After venting, close the regulator by turning the pressure adjusting screw counterclockwise.

10.3 Check for Regulator Pressure Creep

When working properly, regulators should maintain gas delivery pressures as set with the regulatory adjustment controls. The following general procedure may be followed to test if gas cylinder regulator pressure is slowly changing. Regulators should be checked for pressure creep every six months.

1. Attach the regulator to the cylinder.
2. Ensure the regulator is closed by turning the pressure adjusting screw counterclockwise.

3. Slowly open the cylinder valve until it is fully open. Ensure the cylinder has a pressure of at least 1500 psi.
4. Set the delivery pressure gauge to approximately 20 psi and then close off all downstream valves to maintain the pressure in the system. Record the set pressure. Check the pressure after 30 minutes and record the pressure.
5. If the pressure setting has increased, remove the regulator, there may be a problem with the regulator. Return the regulator to the manufacturer for service. A malfunctioning regulatory should never be used.

10.4 Testing for Leaks

A leaking cylinder can pose a serious hazard to individuals working with the gas and to the facility. Further, leaking gas waste research resources and limited budget. Some compressed gases contribute to global climate change. Losses due to leakage are wasteful and unnecessary.

Leak detection procedures should be implemented prior to the initial use of any system using compressed gas. Following, is a general procedure for performing a leak test on a compressed gas system.

For systems where toxic or corrosive gases will be used, first test the system with an inert gas before introduction of the hazardous material.

1. Prepare a soapy water solution, a 50% glycerin-water solution or a commercial leak detection material (such as Snoop by Swagelok). Ensure the solution to be used is not incompatible with the gas in the system.
2. Pressurize the system.
3. Apply the solution to all connections (e.g. cylinder valve, regulator connections, other connections) observing for the formation of bubbles. If bubbles are formed, a leak is present.
4. Gas lines (flexible hose or solid piping) should be checked at least yearly and more often for connections.
5. Inspect and secure connections that are observed to be leaking, and retest.
6. If no bubbles are formed, the system is not leaking, and may be used.
7. If a leak cannot be corrected, the system should not be used. Do not attempt to repair a cylinder valve, connection or flashback arrestor; this work must be completed by trained and certified personnel in a controlled facility. Notify your supervisor who can contact the supplier and take emergency steps if necessary.

11 Cryogenic Dewars (Liquid Nitrogen, Liquid Argon)

Cryogenic gas Dewars are used on campus primarily for liquid nitrogen and argon. Dewars are low to medium compressed gas cylinders. They contain exceptionally cold liquified gases that slowly evaporate into the cylinder. As the liquid evaporates, the pressure within the cylinder increases. When the cylinder over pressurizes, they are designed to safely release the pressure. As a result, cryogenic dewars from the manufacturer may suddenly vent.

If you are near a dewar that is venting from the top, step away and give it time to vent. This is not an urgent condition, but a regular safety feature built into the dewar.

In addition to other risks common to compressed gas cylinders, cryogenic fluids can rapidly cause cold thermal burns and oxygen displacement.

For further information on dispensing or using cryogenic Dewars, please use the Cyogenic Liquid Safety Standard Operating Procedure created by Safety & Risk Services at UBC Vancouver (CHEM-GDL-003).

12 Emergency

In the event of a leaking cylinder, consider the following steps:

- URGENTLY DANGEROUS: Assess urgent needs first.
  - If there is immediate danger, evacuate the building.
    - If the gas is flammable, use your voice to move people out of the area and pull the alarm to evacuate the building from a safe distance.
    - If the gas is NOT flammable, pull the fire alarm station.
  - After evacuation, report to the building warden, Campus Security or emergency personnel present to explain the situation.
    - If Campus Security is not present, call 250-807-8111 from a safe distance.
  - Notify your supervisor after you have discussed with emergency personnel

EXAMPLES OF URGENTLY DANGEROUS CONDITIONS:
- Large uncontrolled leak
- Leak of toxic or flammable gas

- FIRST AID: Call Campus Security if first aid is needed 250-807-8111
  - If injury is severe, call 911.
  - If possible, remove contaminated clothing

- LOWER URGENCY.
  - Report: to your supervisor, who will initiate the appropriate response from the supplier, Campus Security, Health, Safety and Environment, and/or Emergency Services.
  - The supplier should be able to provide advice on appropriate actions.
  - Move the cylinder:
    - If it is safe to move the cylinder and you are trained: move it outside to an isolated, well ventilated area, away from incompatible materials and away from others. Allow it to remain isolated until the gas has discharged.
    - Do not transport in an elevator.
    - Notify Campus security.
  - If the material is toxic or flammable, but you cannot safely move it, secure the area and alert others to evacuate to a safe area. It may be necessary to evacuate the building by pulling a fire alarm.
  - If the materials are inert or non-toxic but you cannot move the tank, open the fume hood sash, press emergency purge on the fume hood and evacuate all lab members to the hallway. Call Campus Security & your supervisor.

EXAMPLES OF LOWER RISK CONDITIONS:
- Slight leak
- Valve that won't close, but gas is being effectively vented

13 Compressed Gas Cylinder Disposal

Hazardous waste is to be disposed of in accordance with the UBC Okanagan Hazardous Waste Disposal procedures that are available on the HSE website. Following, are the general rules that should be followed for the disposal of compressed gas cylinders.

- If possible, purchase compressed gas only from manufacturers that agree to take back the empty cylinders;
- Lecture bottles are very expensive to send for disposal – usually several times more expensive than when full. Labs who purchase lecture bottles will usually be required to pay for disposal costs.
- Never completely empty the cylinder. Always leave a residual gas pressure of 30 psi. Maintaining a residual pressure in an "empty" compressed gas cylinder helps to prevent back flow or suck back. This is the drawing-back into the cylinder of contaminants or moist air from a higher pressure system or the atmosphere which can lead to serious contamination and corrosion problems within the cylinder;
- Always keep the cylinder valve closed on empty tanks. This practice will help maintain the positive pressure required to prevent back flow. As well, an increase in temperature or a drop in atmospheric pressure can force the contents out of a cylinder, with an open valve, into a work space which could result in hazardous conditions depending on the gas and how much is forced out;
- If the research experiment is over and the cylinder still contains hazardous material, the cylinder should be sent back to the supplier for disposal or arrangements made for its transfer to a colleague that will use the cylinder;
- Do not keep gas cylinders in the laboratory beyond the time they are needed. Cylinders have a finite life expectancy. This is especially true for cylinders containing corrosive materials. If you are not using it dispose of it properly; and
- If the cylinder is empty, replace the cap and remove it to the storage area for empty cylinders. If a tag is present remove the bottom portion of the tag (the 'full' tag) leaving the 'empty' tag attached to the cylinder. If no tag is present, very clearly label the tank as empty and place it in a storage area with other empty tanks. Notify your supplier that empty tanks are waiting for pick up.

14 Precautions and Warnings for Commonly Used Gases

Acetylene
A mixture of acetylene and oxygen or air will explode in a confined area in the presence of a spark. Use the appropriate regulator when drawing acetylene from a cylinder (Table 1). Never adjust the regulator for this gas to obtain delivery pressure greater than 15 psig. If the gas is used in high pressure areas, be sure that the pressure gauge plus the ambient pressure does not exceed 30 psi. Under certain conditions, acetylene forms explosive compounds with copper, silver and mercury. Do not use copper fittings or tubing on acetylene tanks. Contact between this gas and these metals, and their salts, must be avoided. It also reacts violently with fluorine and other halogens. Acetylene is thermodynamically unstable and sensitive to shock and pressure. It can polymerize exothermically leading to deflagration. Do not lay acetylene cylinders on their sides. If an acetylene tank has accidentally been left on its side, set it upright for at least one hour before it is used. Use flashback arrestors for hot work activities. In the event a fire propagates through the hose the arrestor will stop the fire from reaching the tank.

Ammonia
Ammonia is an extremely strong irritant and lachrymator. Exposures of 2500 ppm are life threatening. Skin contact with the gas or liquid may result in severe frostbite. Do not touch frosted pipes and valves. Ammonia reacts with diverse compounds to form explosive products. Especially avoid contact with silver, gold and mercury. Always use the appropriate regulator with the gas in use (see Table 1).

Carbon Monoxide
Carbon monoxide is a colorless, odorless, tasteless gas and is highly toxic to humans and animals. Carbon monoxide combines with hemoglobin to produce carboxyhemoglobin, which is ineffective for delivering oxygen to bodily tissues. This condition is known as anoxemia. Common symptoms for carbon monoxide poisoning are headache, nausea, vomiting, dizziness, lethargy and the feeling of weakness. The installation of permanent gas detectors or carrying personal sensing devices for leak detection is required. Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained. Always use the appropriate regulator with the gas in use (see Table 1). An Emergency Response Plan must be in place prior to using this gas.

Chlorine
Chlorine gas is a severe irritant. Inhalation may result in death with exposures of 500 ppm for 30 minutes. Prolonged exposure to chlorine gas can cause olfactory fatigue. Therefore, the installation of permanent gas detectors or carrying personal sensing devices for leak detection is required. Chlorine gas is a strong oxidizer and will support combustion of most flammable materials. Chlorine gas is extremely reactive and reacts violently with hydrogen, hydrocarbons in the presence of light, ammonia, reactive metals and metal hydrides, including silane, phosphine and diborane. Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained. Always use the appropriate regulator with the gas in use (see Table 1). An Emergency Response Plan must be in place prior to using this gas.

Hydrogen

Hydrogen is a flammable gas. A mixture of hydrogen and oxygen or air will explode in a confined area in the presence of a spark. A hydrogen flame is virtually invisible in a well-lighted area. Hydrogen may cause severe frostbite as a liquid or gas. Do not touch frosted pipes or valves.

Take every precaution against hydrogen leaks. Escaping hydrogen cannot be detected by sight, sound, smell or taste. The installation of detectors or carrying personal sensing devices for leak detection is strongly recommended. Because of its low molecular weight, hydrogen tends to collect in high areas, such as at ceiling levels.

A flashback arrestor must be used when working with flammable gases. In the event a fire propagates through the hose the arrestor will stop the fire from reaching the tank.

Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained.

Always use the appropriate regulator with the gas in use (see Table 1).

Hydrogen Cyanide

Hydrogen cyanide is a highly toxic gas. Inhalation can cause fatal respiratory damage. Exposure of 270 ppm is immediately fatal. Exposure of 180 ppm is fatal at 10 minutes. Exposure of 135 ppm is fatal after 30 minutes. The installation of permanent gas detectors or carrying personal sensing devices for leak detection is required.

Hydrogen Cyanide gas is flammable and must be protected from ignition sources.

All supervisors and employees using HCN or cyanide forming gases must have an appropriate exposure response plan in place to immediately begin treatment in case of accidental exposure.

Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained.

Always use the appropriate regulator with the gas in use (See Table 1).

An approved Emergency Response Plan must be in place prior to using this gas.

Hydrogen Sulfide
Hydrogen sulfide is very toxic and flammable. Exposure to hydrogen sulfide concentrations of 150-250 ppm can cause olfactory fatigue. An exposure of 50-100 ppm can lead to eye damage. An exposure of 800 ppm is the lethal concentration for 50% of humans after five minutes of exposure. At concentrations over 1000 ppm immediate collapse with loss of breathing after a single breath can occur. The installation of permanent gas detectors or carrying personal sensing devices for leak detection is required. Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained. Always use the appropriate regulator with the gas in use (see Table 1). An approved Emergency Response Plan must be in place prior to using this gas.

Nitrogen, Argon, Helium and Carbon Dioxide
These gases can all cause rapid asphyxiation and death if released in a confined area. These gases, either as a liquid or gas may cause severe frostbite to eyes or skin. Do not touch frosted pipes or valves. Always use the appropriate regulator with the gas in use (see Table 1).

Oxygen
Oxygen supports and can greatly accelerate combustion of flammable materials. Oxygen, as a liquid or gas, may cause severe frostbite to the skin or eyes. Do not touch frosted pipes or valves. The presence of extra oxygen will decrease the temperature at which materials (including solvents and combustibles) will start on fire. Never use oil or grease on or around oxygen cylinders, valves, fittings or regulator as it may cause fire or explosion. (See Appendix E) Always use the appropriate regulator with the gas in use (see Table 1).

Appendix A. Compressed Gas Association.
The Sleeping Giant.
2019

THE SLEEPING GIANT

Many of us are surrounded by compressed gas cylinders. Here is a reminder of just what respect they command.

GET TO KNOW ME

I can contain very high pressure.
I wear a cap to protect my valve.
I wear a label to identify the gas I am holding.
My color does not tell you what gas I contain.
I am only one piece of a two-part system. Without a correct regulator or manifold, I cannot function safely.

KNOW HOW TO USE ME

Know how to safely install and remove me from your system.
Make sure I am properly secured when in use and when stored.
Open my valve slowly when I am to be used.
Close my valve and replace my cap when you are done.
Know the dangers of my contents, read the SDS, and follow proper procedures when using me.

WHEN THINGS GO WRONG

If my valve or regulator snaps off, all my power is unleashed through an opening no larger than a pencil.
I will become an unguided missile.
I will smash through brick walls.
I will spin, ricochet, and crash through anything in my path.

CGA®
Compressed Gas Association
The Standard For Safety Since 1913

For additional information, see CGA P-1, *Standard for Safe Handling of Compressed Gases in Containers.*

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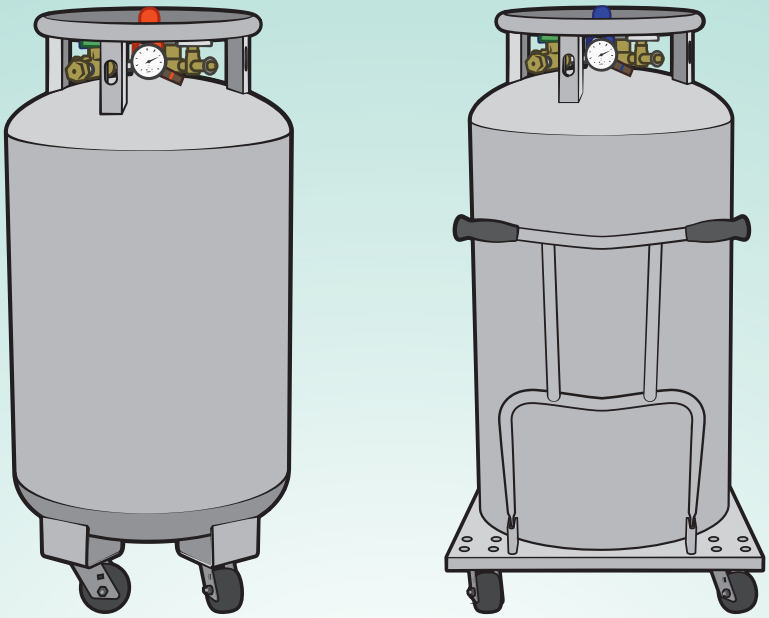
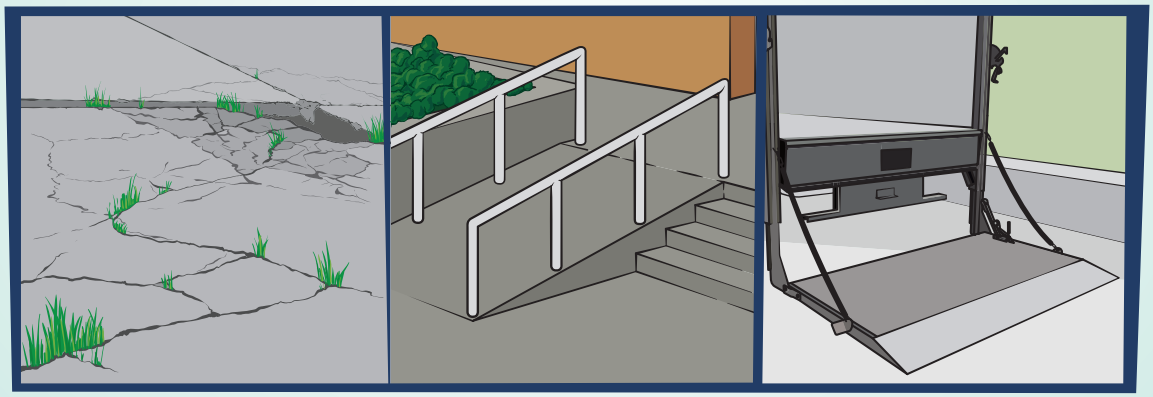
Appendix B. Compressed Gas Association.
Plan Your Trip to Avoid a Tip
2019

PLAN YOUR TRIP TO AVOID A TIP





LIQUID CONTAINERS ON PERMANENTLY ATTACHED WHEEL BASES CAN BECOME UNSTABLE. WATCH FOR TRANSITIONS AND UNEVEN SURFACES.

CGA®
Compressed Gas Association
The Standard For Safety Since 1913

For additional information, see CGA P-84, *Guideline for Safe Handling of Liquid Containers on Wheel Bases.*

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Appendix C. Sign for Unattended Cylinder Transport in an Elevator

THE UNIVERSITY OF BRITISH COLUMBIA

Health, Safety & Environment

WARNING

UNATTENDED COMPRESSED GAS CYLINDER IN TRANSPORT

Do NOT enter this elevator

Lab Destination:_____

Name of Transporter:_____

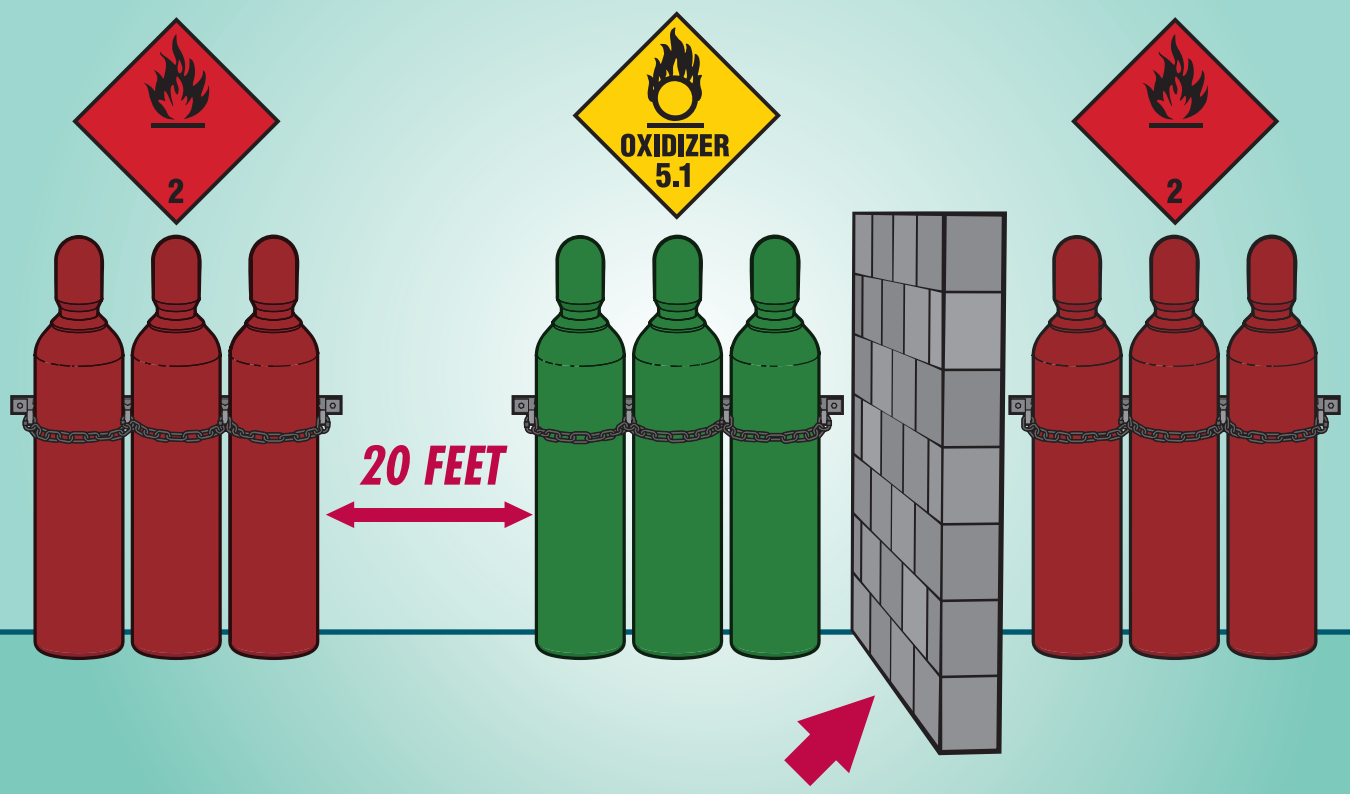
Appendix D: Compressed Gas Association.
Separate Incompatible Gases.
2019

SEPARATE INCOMPATIBLE GASES

MAINTAIN 20 FEET OF SEPARATION

OR

USE A PROTECTIVE BARRIER



BARRIER WITH A 30-MINUTE FIRE RATING THAT INTERRUPTS LINE OF SIGHT

CGA®
Compressed Gas Association
The Standard For Safety Since 1913

For additional information, see CGA P-1, *Standard for Safe Handling of Compressed Gases in Containers*, and NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

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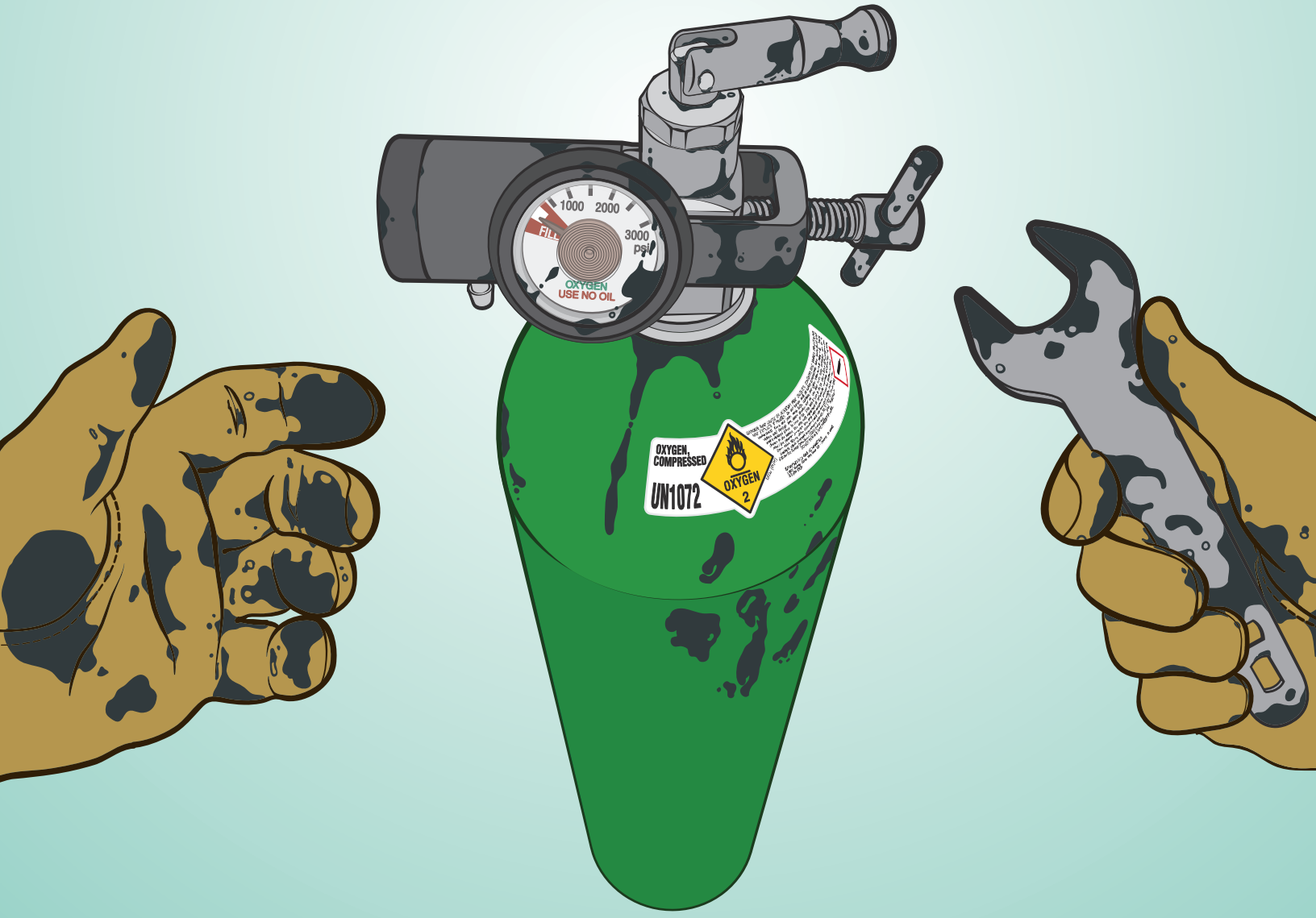
Appendix E. Compressed Gas Association.
Oxygen Contact with Oil/Grease is Dangerous and Could Lead to Fire or Explosion
2019

OXYGEN CONTACT WITH OIL/GREASE IS DANGEROUS AND COULD LEAD TO FIRE OR EXPLOSION



KEEP OXYGEN SYSTEMS CLEAN AND FREE OF OIL, GREASE, AND OTHER HYDROCARBON MATERIALS

CGA®
Compressed Gas Association
The Standard For Safety Since 1913

For additional information, see CGA P-1, *Standard for Safe Handling of Compressed Gases in Containers.*

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