Compressed and Liquefied Gases
Document No. LAB-002-02

1. INTENT

This Standard Operating Procedure (SOP) applies to all faculty, staff and students at Wilfrid Laurier University. It was developed by Safety, Health, Environment & Risk Management (SHERM) to outline safety precautions for the management and use of compressed and liquefied (cryogenic) gases. Questions regarding this SOP can be directed towards SHERM at extension 3108.

2. DEFINITIONS

Compressed Gas
Any material or mixture in a container where the absolute pressure is greater than 40 psi at 20°C.

Liquefied (Cryogenic) Gas
A gas, which when compressed in a container, becomes a liquid at ordinary temperatures and at pressures ranging from 25 to 2500 psig.

3. GENERAL GUIDELINES

Compressed Gases

Compressed gases are inherently hazardous due to the high pressure inside the cylinders. Knocking over an unsecured, uncapped cylinder of compressed gas can break the cylinder valve and result in a rapid escape of high-pressure gas that can transform a cylinder into an uncontrollable rocket or pinwheel, causing serious injury and damage. Always keep cylinders secured while in use and in storage. Compressed gases may also have flammable, oxidizing, dangerously reactive, corrosive or toxic properties. Inert gases such as nitrogen, argon, helium and neon can displace air, reducing oxygen levels in poorly ventilated or restricted areas and cause asphyxiation.

Liquefied (Cryogenic) Gases

Cryogenic liquids such as liquid nitrogen, helium, and oxygen are, by definition, extremely cold. Contact between cryogenic liquids and exposed skin can produce a painful burn. A splash of cryogenic liquid to the eye can cause loss of vision. Always wear proper personal protective equipment including a buttoned lab coat, long pants, heavy gloves, and a face shield/safety goggles whenever handling cryogenic liquids.

4. PROCEDURES

4.1 Compressed Gases

4.1.1 Storage

- Cylinders containing non-flammable gases will be stored in designated areas in the loading docks at both the Science Research Building and Centre for Cold Regions and Water Science (CCRWS) on the Waterloo Campus.
- Cylinders containing flammable materials are stored in a designated outdoor enclosure on the northwest corner of the Science Building. There is no storage for flammable gases at CCRWS, and therefore flammable gas cylinders must be ordered for use on an as-needed basis.
- Signage indicating the nature and hazard of the gases being stored are located at the entry of the storage areas, including a non-smoking sign at the outdoor facility.
- Full and empty cylinders must be segregated in both the indoor and outdoor locations. Empty flammable gas cylinders are stored outside in the partition labelled "Empty Cylinders", and empty non-flammables inside along the railing.
- When a cylinder is moved in or out of the designated storage area, record the date, your name, type of gas and cylinder pressure (if returning cylinder) into the log book that is located in the cylinder storage area.
- Never keep more than the minimum number of required cylinders in the laboratories. Extra cylinders should always be stored in the designated storage areas.
- Cylinders containing gases that may react with one another shall not be stored adjacent to one another (i.e. oxygen and hydrogen).
- Nothing other than the gas cylinders is to be stored with the gases, particularly anything flammable or combustible.
- In the laboratory, all cylinders must be secured individually to a wall, bench or fixed support using a chain or strap placed 2/3 high on the cylinder body. Cylinder stands may be used as an alternative to straps.
- Cylinders should not be stored near radiators or other heat sources. No part of a cylinder should be subjected to a temperature higher than 52°C. A flame should never be permitted to come in contact with any part of a compressed gas cylinder.
- Do not place cylinders where they may become part of an electric circuit.
- Keep cylinders upright.

4.1.2 Transportation between Laboratories and Storage Areas

- When cylinders are being transported, regulators must be removed and the protective cap must be attached.
- A cart for transporting the cylinders is located in the indoor storage areas at both the Science Research Building and CCRWS. The cart can be used to transport cylinders to and from the indoor and outdoor facilities, but must be returned to the indoor storage area after use.

- Cylinders must be chained or strapped to the cart during transportation.
- If the walkway between the outdoor storage facility and the door to the building is unsafe due to snow or ice accumulation, contact Physical Resources at extension 6280 to request the walkway be cleared before moving the cylinder.
- If a cylinder begins to fall, never attempt to catch it. The cap covering the cylinder valve will protect the valve from damage.
- When transporting a cylinder in the elevator, do not travel in the elevator with the cylinder. Cryogenic cylinders present the greatest hazard because they vent periodically and become a risk if the vent valve gets frozen open. Post a sign on the inside of the elevator to indicate no passengers are permitted and use the buddy system to put the cylinder on the elevator and remove it at the destination floor.

4.1.3 Setup and Installation

- Fittings do not need to be lubricated. Oil and grease should never come into contact with attachments or cylinders.
- Never use Teflon tape on fittings as the tape may become lodged in the piping and cause a blockage.
- Read the label on the cylinder before connecting a new cylinder of compressed gas. If the label is illegible or missing, return the cylinder to the supplier. Colour coding does not provide sufficient identification. Never use a cylinder with unidentified contents.
- If a gas cylinder valve is damaged, the contents can exit with great force. Cylinders should be affixed via two brackets to a permanent building fixture such as a bench or wall during use or storage. Brackets that can be screwed into the mounting surface are preferred over clamp-type brackets. When the cylinder has no regulator attached, replace the valve cover.
- Flammable gases require non-sparking, i.e. brass, fittings.
- Copper tubing is not to be used with acetylene gas, as copper forms explosive compounds with acetylene.
- Cylinders containing flammable gases must be grounded to prevent accumulation of electrostatic charge.

4.1.4 Regulator Safety

- Cylinder valve connections on regulators are designed to minimize the chances of using the wrong regulator.
- Verify that the regulator is appropriate for the gas being used and the pressure being delivered. Regulators are not universal and have to be chosen based on the gas and the cylinder in use. They cannot be used interchangeably.
- The Compressed Gas Association (CGA) has devised a system that ensures accidental mix-ups cannot occur. Each cylinder and regulator has connection fittings that are designated by a CGA connection number. Below are some common CGA connection numbers. High pressure tanks or lecture bottles require different fittings:

Gases	CGA Connection #
Carbon dioxide	320
Boron trifluoride, hydrogen chloride, hydrogen bromide, hydrogen iodide, hydrogen sulfide, silicon tetrafluoride	330
Carbon monoxide, ethylene, hydrogen, hydrogen selenide	350
Acetylene, allene, butadiene, butane, butenes, cyclopropane, dimethylether, methane, propane, propylene, vinyl methyl ether	510
Oxygen	540
Argon, nitrogen, helium, noble gases	580
Air (industrial grade)	590
Boron trichloride, chlorine, nitric oxide, nitrogen dioxide, nitrogen trioxide, sulfur dioxide, phosphorous pentafluoride, many halocarbons	660
Anyhdrous ammonia	705

- CGA connection numbers are typically (but not always) stamped on the regulator just above the threads of the cylinder connection. Some will even state specifically which gas for which they can be used.
- Never attempt to use a cylinder without a pressure regulator.
- Do not lubricate regulators. The mixture of lubricant and oxidizing gases could be explosive.
- As with all fittings in a gas system, do not use adaptors or Teflon tape to attach regulators to gas cylinders. Regulator inlet connections are designed to fit the outlet connection of the cylinder valve of a particular gas. Gas tight connections are made using metal-to-metal seals and can be weakened or the lines plugged through the use of Teflon tape.
- When tightening the regulator nut and hose connections, always use a cylinder wrench or other tightly fitting wrench. Do not use an oversized wrench, adjustable wrench, pliers or pipe wrench. These tools may damage the fittings and make it impossible to tighten them properly.
- Any regulators that are found to be leaky should be returned to the manufacturer for replacement or repair.

4.1.5 Handling

- Consult the Material Safety Data Sheet for all gases before use. Some gases are corrosive (hydrogen chloride), toxic (ethylene oxide), anaesthetic (nitrous

oxide), or highly reactive (anhydrous ammonia). As with all chemicals, be sure to understand the properties of the gas before commencing work.

- To use a cylinder:
  - Ensure the pressure regulating valve (pressure adjusting screw) is closed.
  - Open the cylinder valve slowly.
  - Open the pressure regulating valve to the desired pressure.
- To shut off the gas:
  - Close the cylinder valve.
  - Open the pressure regulating valve to relieve the pressure.
- Never bleed a cylinder completely empty; leave a residual pressure of at least 100 psi to prevent contamination gases from returning to the cylinder.
- Never expose skin or clothing to compressed gas flow as high velocity gas could penetrate the skin and cause serious injury.
- Refilling the cylinders by anyone other than the supplier is strictly prohibited.

4.1.6 Replacement of Cylinders

- Label empty cylinders clearly with either "EMPTY" or "MT", or "Empty" tag to indicate that it is empty.
- Move empty cylinders into the designated space in the storage area to await pickup to return to supplier.
- Leak testing of any connections that have been loosened or opened during replacement should be performed at the time of cylinder replacement. Leak testing of connections should be performed periodically while the cylinder is in use.
- A solution such as "Swagelok Snoop" or non-petroleum based soap and water can be used to test for leaks. Apply a stream of liquid leak detector to a pressurized connection. Formation of bubbles at the connection indicates leakage.

4.1.7 Lecture Bottles

Lecture bottles are very small compressed gas cylinders, typically 2-3 inches in diameter and 12-18 inches in height. While most gas suppliers offer lecture bottles for purchase, many will not accept the return of empty or partially full cylinders for disposal. Lecture bottle disposal can be very costly, depending on the original contents.

- Only purchase lecture bottles that can be returned to the distributor. Most distributors offer a returnable cylinder, although in some cases, these cylinders are slightly larger than typical lecture bottles. The costs associated with disposing of lecture bottles that cannot be returned to the distributor will be charged to the user's department.
- It is worthwhile to purchase a returnable cylinder, even if it contains slightly more gas than is required due to the high cost of lecture bottle disposal.
- Secure lecture bottles using a bench-top stand designed especially for the small size of the cylinders.

4.1.8 Emergency Situation – Leaking Cylinder

- Inert gases, such as nitrogen and carbon dioxide must be treated with caution. If left to leak into closed space, these gases may displace oxygen and create a risk of asphyxiation.
- Most leaks occur at the valve in the top of the cylinder and may involve the valve threads, valve stem, valve outlet, or pressure relief devices.
- Lab personnel should not attempt to repair leaking cylinders.
- If a large or uncontrollable leak occurs, evacuate the area immediately and call 911 and extension 3333 at the Waterloo Campus or extension 5888 at the Brantford Campus.

4.2 Liquefied (Cryogenic) Gases

4.2.1 Storage

- Pressure build-up and extreme cold are the main hazards associated with cryogenic gases.
- Cryogenic liquids must be stored in a self venting container or a dewar with a loose lid.
- Always store cryogenic liquids in a well ventilated area. If the liquid is allowed to vaporize in a closed space, it will displace oxygen and cause asphyxia.

4.2.2. Transportation

- Always push a container, never pull. See diagram for proper procedures.
- If a cylinder begins to fall, never attempt to catch it. The cap surrounding the cylinder valve will protect the valve from damage.
    - Allow it to settle for 15 minutes and examine the cylinder for structural integrity before approaching it.
    - Wear a full face shield and gloves while handling the cylinder.
    - A minimum of two people are required to return the cylinder to an upright position using a mechanical lifting device.
    - Notify the supplier of the incident.
    - If the container rapidly builds pressure or shows any signs of malfunction, vent it carefully into a well ventilated safe area and call the supplier for further instruction.
- When transporting a cylinder in the elevator never travel in the elevator with the cylinder. Cryogenic cylinders present the greatest hazard because they vent periodically and become a risk if the vent valve gets frozen

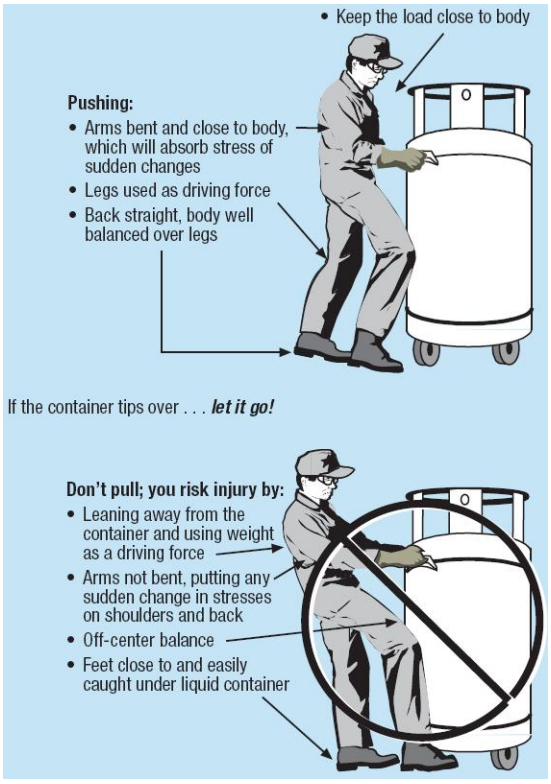

Image: airproducts.com

open. Post a sign on the inside of the elevator to indicate no passengers are permitted and use the buddy system to put the cylinder on the elevator and remove it at the destination floor.

4.2.3. Handling and Use

- Become familiar with the container and the valves on the container that you will use. See the diagram below for typical high and low pressure container design.

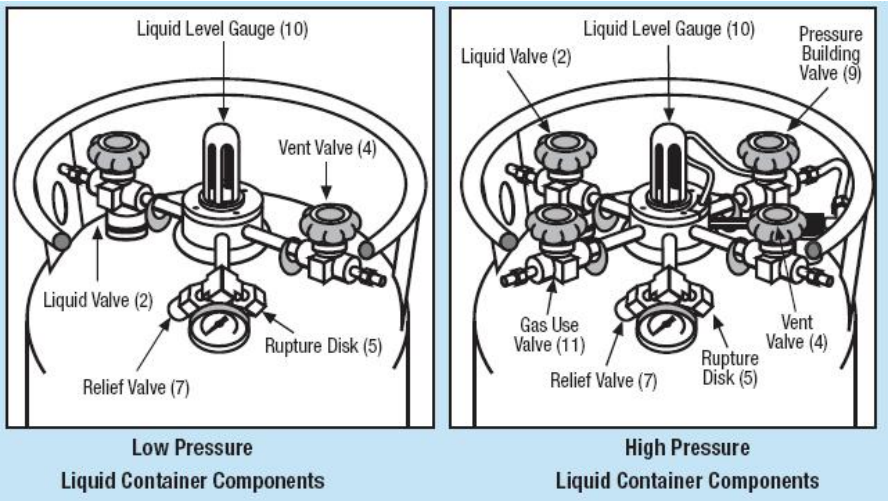

Image: airproducts.com

- Low pressure containers operate at pressures up to 22psig, high pressure containers operate at up to 230psig.
- Always ensure regulator and container pressure compatibility prior to making connections.
- The extremely cold temperature of cryogenic liquids can rapidly freeze human tissue, therefore leather or insulated gloves are to be worn when the potential for contact with the liquid or cold piping exists. Long pants, a long sleeved shirt, safety glasses and a face shield should be worn when handling the liquid.

4.2.4 Disposal

- Cryogenic liquids should not be disposed of down the drain. Ordinary materials such as metal or polyvinylchloride (PVC) piping in laboratory sinks may not be able to withstand cryogenic temperatures.
- Allow cryogenic liquids to evaporate in a fume hood or other well ventilated area if not contained within a cylinder.
- If contained within a cylinder, send it back to the manufacturer.

4.2.5 Spill

- The major hazard of a cryogenic liquid spill is the evaporation resulting in displacement of oxygen and an asphyxiating atmosphere, or the fire and

explosion hazards from evaporation of flammable gases or condensation of oxygen. In addition, glass and other materials may shatter upon contact with cryogenic fluids.

- A small spill of liquid will produce a large volume of gas which will change the conditions of the ambient environment in a confined space very quickly. See the chart below for expansion ratios.

Liquid to Gas Expansion Ratios at 21°C

Cryogenic Liquid	Expansion Ratio
Argon	1 to 841
Helium	1 to 754
Hydrogen	1 to 848
Nitrogen	1 to 696
Oxygen	1 to 861

*For example, 1 cubic foot of liquid argon will create 841 cubic feet of gaseous argon at 21°C.

- Normally a small splash or spill will rapidly evaporate into the atmosphere. In the event of a large spill, the employee should restrict access to the work area and dial 3333 at the Waterloo Campus or 5888 at the Brantford Campus.

5. APPENDIX

Relevant Standards

Laboratory Health and Safety Manual, Safety, Health Environment & Risk Management.

6. REVISION HISTORY

Revision	*Date*	*Comments*	*Initials*
00	Jun 13/08	SOP comes into effect	SJL
01	Feb 11/10	Updated §4.1.2, §4.2.2-elevator transport	SJL
02	Apr 25/16	Updated to include CCRWS	SJL

ACKNOWLEDGMENTS

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