Western Carolina University Compressed Gas Program

This document has been developed to provide guidance for the proper storage, use, and disposal of compressed gases and cryogens at Western Carolina University. The program is implemented and maintained by the Office of Safety and Risk Management.

Office of Safety and Risk Management *June 2017*

EMERGENCY TELEPHONE NUMBERS

(A larger copy is available at the end of this document to post by your laboratory telephone)

	Phone	Hours
Safety and Risk Management Office • Work Related Injuries *(Normal Business Hours)* • Gas Leaks or Odors • Chemical Spills • General Inquiries	828-227-7443	8:00am - 5:00pm Monday-Friday
University Police Department • Work Related Injuries (*After Normal Business Hours)*	Police Services – 828-227-7301 Emergency Line – 828-227-8911	24 hours
Fire or Smoke	911 or University Police 828-227-8911	24 hours
Medical Emergencies	911 or University Police 828-227-8911	24 hours
NC Poison Control Center	1-800-84 TOXIN (1-800-848-6946)	24 hours

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Overview

Compressed gas cylinders can present a variety of hazards due to their pressure and contents. This manual covers the requirements which must be followed for the use of all compressed gases on campus. In addition to the standard required work practices for inert gases, hazardous gases may require additional controls and work practices including, but not limited to, the use of gas cabinets, gas monitors, emergency shutoffs, proper equipment design, leak testing procedures, and the use of air supplying respirators for certain highly toxic gases. Contact the Safety and Risk Management Office for further assistance with the safe design of equipment involving the use of hazardous gases.

Laboratory principal investigators and work supervisors are responsible for assuring that the requirements of this manual are followed by all personnel under their supervision who use or handle compressed gas cylinders during the course of their work.

Section 1: Compressed Gas Safety

1.1 Compressed Gas Use Applications

Use of Inert Gas: Inert gases are non-flammable and non-toxic but may cause asphyxiation due to displacement of oxygen in poorly ventilated spaces. Inert gases commonly found on campus include Carbon dioxide, Argon, and Nitrogen gas.

Use of Flammable, Low Toxicity Gases

These gases are flammable but act as non-toxic simple asphyxiants. Examples include hydrogen, acetylene, and methane. Flammable gases can be ignited by static electricity or by a heat source such as a flame or hot object. Oxygen and other oxidizing gases will support combustion of flammable materials and must be kept separate from flammable gases.

Use of Pyrophoric and Highly Reactive Gases and Liquids

These gases spontaneously ignite on contact with air at a temperature of 130°F or below. Examples include phosphine, arsine, silane, diborane, and anhydrous ammonia. Silane has caused major losses due to fires in ducts, gas cabinets, and supply systems and most incidents have occurred in research facilities. Pyrophoric fires are difficult to extinguish.

Use of Corrosive, Toxic, and Highly Toxic Gases

These gases may cause acute or chronic health effects at relatively low concentrations in air. Corrosive gases can cause rapid destruction of skin tissue and can chemically attack various materials, including fire-resistant clothing. Some gases are not corrosive in their pure form, but can become extremely destructive if a small amount of moisture is added. Chemical poisoning is the primary hazard of toxic gases, and even in very small concentrations, brief exposure can result in serious poisoning injuries. Examples of these gases include hydrogen chloride, ethylene oxide, nitrous oxide, carbon monoxide, and hydrogen sulfide.

Use of Compressed Gases in Fume Hoods

Toxic gases, such as carbon monoxide and hydrogen sulfide should be stored and used in a chemical fume hood. Since fume hood face velocities provide insufficient protection against pressurized gas leaks, special care must be taken when hazardous gases are used in fume hoods. The following is required for fume hood applications:

- Use the smallest possible cylinder size and when possible order returnable bottles with the lowest cylinder pressures.
- Use a flow restricting orifice or needle valve to restrict flow to only that needed for the experiment.
- Toxic and corrosive gases must be used with a normally closed, pneumatic shutoff valve located immediately downstream of the cylinder regulator and which closes with exhaust loss or power failure.
- Place the cylinder in the rear of the hood to prevent high pressure leaks from escaping out of the hood.
- Ensure all components in the experiment can withstand full bottle pressure.
- Keep all purge lines and gas supply lines within the hood.

Use of Fuel Gases for Welding, Cutting, Brazing

These gases are used for welding and cutting applications. Common examples include oxygen, propane, and acetylene.

1.2 General Compressed Gas Safety Practices

1. Wear appropriate Personal Protective Equipment (PPE) when transporting, connecting and disconnecting gas regulators and transfer lines.
   - Approved safety glasses
   - Closed-toed shoes
   - Gloves and clothing to protect skin from frostbite (cryogens), corrosives, or pinch points.
   - Face shield if face protection is necessary.
2. Always check the label on the cylinder. It should be legible and clearly indicate the contents with either the chemical or trade name of the gas.
   - Never accept a cylinder that is not labeled correctly
   - Do not rely on the color coding of the tanks/caps, this is not a reliable indicator of what is inside the tank.
   - If the labeling on the gas cylinder becomes unclear or defaced so that the contents cannot be identified, the cylinder should be marked “contents unknown” and the manufacturer must be contacted regarding appropriate procedures for removal.

1.3 How to Properly Secure Compressed Gas Cylinders

All gas cylinders must be secured at all times with proper securing devices such as straps and clamps. Cylinders must be secured when full and when empty. The screw on cylinder caps must be in place at all times when the regulator is not connected to provide mechanical protection. Regulators must be removed and cylinder caps replaced prior to movement of compressed gas cylinders.

- Strap/chain the gas cylinder to a secure fixture at a height of 1/2 to 2/3 of the cylinder height.
- Secure fixtures include a properly secured wall mount, properly maintained and securely tightened bench mount, or secure floor support that doesn't present a tripping hazard.
- Strap each individual cylinder rather than strapping a group of cylinders together.

1.4 How to Properly Store Compressed Gas Cylinders

- Always store the cylinders upright with valve caps in place when not in use.
- Segregate full and empty cylinders.
- Separate flammable gases from oxidizing gases and other combustible materials (separation distance of 20 feet or a 5 foot high fire-rated wall).
- Store cylinders in a cool, dry, well-ventilated, and secure area.
- Cylinder storage areas should be protected from extreme heat or cold, prevent temperatures from exceeding 125°F, and should have limited access to only authorized personnel.
- Store away from heavily traveled areas and emergency exits.
- Visually inspect storage areas on a routine basis for any indication of leakage or problems.
- Post signage in the storage area to indicate potential hazards (flammable gas, oxygen, etc.).

1.5 How to Properly Handle Compressed Gas Cylinders

Compressed gas cylinders should be handled only by personnel who have been properly trained. Cylinders are heavy and awkward to move and improper handling can result in serious injury. Use the following precautions when handling compressed gas cylinders:

- Never drag, roll, or slide containers.
- Always leave the valve protection cap in place when transporting the cylinder and when securely stored until ready to be used.
- Always use a suitable cart to transport cylinders.
- Don't try to catch a falling cylinder.
- Don't allow grease or oil to come in contact with oxygen cylinder valves, regulators, gauges or fittings; an explosion or fire can result. Oxygen cylinders and apparatus must be handled with clean hands and tools.
- Refer to the SDS for the gas and use the proper precautions and PPE.

- Always use the regulator approved for the specific gas. Do not force cylinder valve connections that do not fit.
- Open the cylinder valve slowly, directed away from your face.
- Do not attempt to refill compressed gas cylinders; this can only be done by a qualified manufacturer of compressed gases.
- Only use non-sparking tools when working with flammable gases.
- When finished using the gas close the cylinder valve and release all pressure from the downstream equipment. Disconnect the cylinder anytime there is an extended non-use period and cap the cylinder.

1.6 Regulators, Tubing, and Piping Connections

- Gases must be dispensed using systems that are cleaned and compatible with the gas in use. Use hard piping (copper, stainless steel) when possible, as opposed to flexible or plastic tubing. When flexible tubing is used, select compatible tubing and use it within line of sight (not under doors, through walls, ceilings). Replace old flexible tubing before it deteriorates. Secure tubing to keep it in place.
- Don't use Teflon tape on cylinder connections. Use Teflon only on pipe threads where the seal is made at the threads. Always leak-check tubing or piping connections.
- Regulators reduce the high pressure gas to a lower usable level and provide additional safety measures. Only use a regulator for the gas for which it is intended and never force a connection.

1.7 Lecture Gas Bottles

Lecture bottles are small compressed gas cylinders, typically 12-18 inches long and 2-3 inches in diameter. They are typically used for holding calibration gases or in applications that require smaller quantities of gas. The following precautions should be followed for storing and using lecture gas bottles:

Lecture Bottle Use:

- Inspect the bottle and regulator before use and never use if corroded or damaged.
- Only use regulators and tubing appropriate for the gas (i.e. Use stainless steel for corrosive gases). Using the wrong regulator can compromise gas purity, cause equipment failure, and result in injury to personnel.
- Label the regulator with the gas it is to be used for to prevent improper use.
- Properly secure the cylinders in an upright position using an approved lecture bottle stand during use.
- Lecture bottles containing toxic gases (i.e. Hydrogen sulfide, carbon monoxide, nitrous oxide) must be used in a fume hood or gas cabinet.

Lecture Bottle Storage:

- Ensure that lecture bottles are stored upright and secured in a way to prevent them from falling. Lecture bottle holders can be purchased for this purpose.
- Non-corrosive gas cylinders may be stored horizontally in specifically designed racks to prevent movement. Do not stack cylinders.
- Remove the regulator when storing cylinders.
- Separate incompatible gases such as flammable and oxidizing gases. Store poisonous gases in a fume hood or ventilated gas cabinet.
- Lecture bottles must be properly labeled with contents, date received, and hazards.
- If the bottle is completely empty (no material will escape if the valve is opened), clearly label as "empty" and store separately.
- Anhydrous hydrogen fluoride lecture bottles must be disposed of within 2 years of purchase. Over time the HF reacts with iron in the steel container to form iron fluoride and hydrogen gas. The hydrogen pressure can build up and cause the cylinder to rupture!

Lecture Bottle Purchase and Disposal

- Lecture bottles may not be refillable or returnable to the gas manufacturer and the disposal cost can be significant. This is something to keep in mind when purchasing lecture bottles, and we recommend that laboratories purchase from vendors who do take back lecture bottles, whenever possible. Sigma Aldrich and Matheson Tri-Gas are two such vendors that may take back bottles for a small fee if they have been purchased from them and are in good condition.
- Contact the Safety and Risk Management Office if you have gas lecture bottles to dispose of (828-227-7443).

Section 2: Cryogenic Liquids

2.1 Introduction

A cryogenic liquid is defined as a liquid with a normal boiling point below 240°F (-150°C). Only inert gases are permitted in portable cryogenic containers. Liquid oxygen, liquid hydrogen or other flammable or toxic cryogenic liquids are not permitted.

All cryogenic liquids should be used with caution due to the low temperature and hazards associated with pressure buildup in enclosed piping or containers. Portable containers should only be used where there is sufficient ventilation. Do not place containers in an enclosed space where there is no ventilation supply to the area as the buildup of inert gas in such an area could generate an oxygen deficient atmosphere and result in asphyxiation.

2.2 Precautions

Cryogenic liquids are extremely cold and can rapidly freeze human tissue on contact. Prolonged exposure can cause frostbite. There is no initial pain but there will be intense pain when frozen tissue thaws. Unprotected skin can stick to surfaces (particularly metallic surfaces) cooled by cryogenic liquids and then tear when pulled away. Prolonged breathing of extremely cold air may damage the lungs. When transferring cryogens, loose fitting cryogenic handling gloves must be used and precautions taken to eliminate exposed skin and protect the eyes. Containers to be filled with cryogenic liquids should be filled slowly to avoid splashing.

Use and store cryogenic fluids in well ventilated areas only. Tremendous pressures can develop in enclosed spaces as the liquid converts to gas. For example, one cm^3 of liquid nitrogen will expand to 700 times this volume as it converts to its gaseous state. Vacuum jacketed containers, designed to minimize heat loss, will have overpressure relief valves in place and cryogenic liquids will vent as part of normal operation. As an example, a 160 liter tank will vent the gas equivalent to 2 liters of liquid a day. Excessive venting or an isolated ice build-up on the vessel walls may indicate a fault or problem and if this occurs the vessel should be removed from service and taken to a safe well-ventilated area immediately.

All cryogenic liquids produce large volumes of gas when they vaporize and can displace the normal oxygen volume in enclosed spaces. When the oxygen content (normally 21%) is reduced to 15-16%, an individual will lose consciousness without warning. When there is not enough oxygen, asphyxiation and death can occur very quickly! Even a few breaths of oxygen-depleted air can cause a rapid drop in dissolved oxygen in the blood resulting in mental failure and coma within seconds.

2.3 General Safety Practices

- All cryogenic liquids must be stored in a well ventilated area.
- Dewars are non-pressurized, vacuum-walled containers that are equipped with a loose-fitting cap or open top and should be used for small amounts of cryogenic liquid.
- Cryogenic liquid containers that are sealed, vacuum-walled, and fitted with pressure release valves should be used to store cryogens. Dewars can be filled from these containers.
- Use the recommended PPE for handling cryogens: loose fitting thermal insulated or leather gloves, long sleeved shirts and trousers, and safety glasses.
- Do not wear metal jewelry, rings, watches, etc., while transferring cryogenic liquids.
- Transfer cryogens slowly to avoid splashes. Open transfers are allowed only in well-ventilated areas.
- Use tongs or other devices to immerse and remove objects from cryogenic liquids.

2.4 Dewar Safety

Dewars are usually used for liquid nitrogen. Contact of liquid nitrogen or any very cold gas with the skin or eyes may cause frostbite injury. The gas issuing from the liquid is extremely cold. Delicate tissue, such as that of the eyes can be damaged by an exposure to the cold gas which would be too brief to affect the skin of the hands or face. Protect hands and eyes at all times when working with liquid nitrogen. Always wear cryogenic gloves that are loose fitting and can be thrown off quickly if liquid should splash into them. Any kind of canvas shoes should be avoided because a liquid nitrogen spill can be taken up by the canvas resulting in a far more severe burn.

Do not use any stopper or other device in the opening of the liquid nitrogen dewar that would interfere with venting of the gas. Inadequate venting can result in excessive gas pressure which could damage or burst the container.

Use a phase separator or special filling funnel to prevent splashing and spilling when transferring liquid nitrogen into or from a dewar. Use only small, easily handled dewars for pouring liquid. For larger containers, use a cryogenic liquid withdrawal device to transfer liquid from one container to another. Be sure to follow instructions supplied with the withdrawal device. Avoid overfilling the containers to prevent spillage of liquid.

2.5 Transporting Cryogen Containers

Move cryogenic liquid containers carefully. Do not move a container by rolling it on its lower rim. Always use a hand truck, cart, or other proper handling device. Use a strap to secure the container to the handcart. Keep the containers upright at all times except for minor tilting on the cart during transport. Always push rather than pull the container as pushing reduces the chance of the container falling on you or a co-worker.

If cryogens must be transported by elevator, take adequate precautions to prevent possible injury. Send the cryogenic liquid container in the elevator without any passengers and have people stationed at each floor to ensure that no passengers get on the elevator while the cryogen is being transported. Place someone at the destination floor to retrieve the cylinder. This process will ensure that if a power failure occurred, or if the tank malfunctioned, a passenger would not be trapped in the confined space of an elevator with the cryogen. Excessive amounts of the cryogen could vaporize and displace the oxygen in the elevator, quickly creating an asphyxiation hazard.

2.6 Emergency Procedures

Asphyxiation - Never enter an area suspected of being oxygen-deprived without a source of supplied air. Use monitoring devices to ensure oxygen levels are adequate.

Anyone suffering from lack of oxygen should be quickly moved to an area with normal atmosphere. If the victim is not breathing, artificial respiration should be administered immediately. Give supplemental oxygen with respiration if oxygen is available.

Frostbite - For skin contact remove any clothing that may restrict circulation to the frozen area. Do not rub frozen parts as tissue damage may result. Place the affected area in a warm water bath with a temperature that does not exceed 105ºF (40ºC). Do not apply dry heat. Seek medical treatment as soon as possible. Frozen tissue is usually pain-free and appears waxy with a possible yellow color. It will become swollen, painful, and prone to infection when thawed.
Faulty Equipment - If a Dewar or larger container of cryogenic liquid is venting continuously or forming ice on the surface, call the supply vendor immediately.

Section 3: Training Requirements

Any employee who physically transports and makes regulator connections to compressed gas systems is required to take the compressed gas safety training. Contact the Safety Office directly to be enrolled in this training if you have not previously indicated this as a job duty on the Hazard Assessment Training Determination Form. Lab specific training provided by the PI or Lab Supervisor is considered adequate for personnel who connect tubing and adjust flow valves for inert, flammable and low toxicity gases used in the lab.

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Lab Supervisor Contact		
Name	*Phone*	*Hours*