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Compressed Gas and Cryogenics Safety Program

UNC CHARLOTTE
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I. Purpose

UNC Charlotte continually strives to provide a learning, teaching, and research environment free from recognized hazards. The University requires the safe handling, use, and storage of compressed gas cylinders to protect employees and students from potential physical and health hazards associated with using compressed gases in laboratories or other locations that are part of the University.

II. Scope

UNC Charlotte wants to ensure employees who handle compressed gases understand the health and physical hazards of the compressed gas cylinders, the contents, proper handling, use, storage, and emergency procedures. To accomplish this, the Environmental Health and Safety (EHS) Office will ensure compliance to the Occupational Safety and Health Administration (OSHA) [29 CFR 1910.101-105, 110, 111, 29 CFR 1910.253](#), and the [State of North Carolina Fire Code](#) (NCFC). This program applies to the storage, use, and handling of gases in pressurized portable containers and gas systems. The primary focus of this program is on single gas uses and systems. Additional requirements may be applied to:

- A. Large, compressed gas facilities, storage areas, or use areas.
- B. Use of multiple gases in a single control area or building.

Note: The UNC Charlotte Compressed Gas and Cryogenics Safety Program does not apply to refrigerant gases, as these substances are regulated under separate guidelines and regulations. Refer to the UNC Charlotte Refrigerant Management Program.

III. Definitions

- A. Asphyxiant Gas. A gas, usually inert that may cause suffocation by displacing the oxygen in the air necessary to sustain life or is labeled by the DOT as Division 2.2 (non-flammable, non-poisonous compressed gas).
- B. Compressed Gas. A gas, or mixture of gases, having an absolute pressure exceeding 40 psi at 70 degrees F (21.1 degrees C); or a gas, or mixture of gases, having an absolute pressure exceeding 104 psi at 130 degrees F (54.4 degrees C) regardless of the pressure at 70 degrees F; or, a liquid having a vapor pressure exceeding 40 psi at 100 degrees F (37.8 degrees C) as determined by ASTM D-323-72.

- C. Corrosive Gas. A gas that causes visible destruction of, or irreversible alterations in living tissue by chemical action at the point of contact or is labeled by the DOT as Division 2.3 (Toxic Gas) and Division 8 (Corrosive Substances).
- D. Cryogenic Liquid. A gas that is condensed to liquid form at extremely low temperatures. Example: Liquid Nitrogen is -196°C (-320°F). The term “cryogenics” applies to all temperatures less than -150°C (-238°F).
- E. Flammable Gas. A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or, a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air greater than 12 percent by volume, regardless of the lower limit; or, one for which the DOT requires their flammable gas label or is labeled as Division 2.1 (Flammable Gases).
- F. Hazardous Gas. A gas that is included in one or more of the following GHS hazard categories: corrosive, flammable, health hazard, oxidizer, pyrophoric, reactive, or toxic.
- G. Oxidizing Gas. A gas that is non-flammable but can support and vigorously accelerate combustion in the presence of an ignition source and a fuel or is labeled by the DOT as Division 2.2 (non-flammable, non-poisonous compressed gas) and Division 5.1 (Oxidizer).
- H. Toxic Gas. A gas that has a median lethal concentration in air of 2,000 parts per million or less by volume of gas; or, gas which the DOT requires the poison label or is labeled as Division 2.3 “Gas poisonous by inhalation” because it is known to be so toxic to humans as to pose a hazard to health during transportation; or a gas that has an NFPA Health Hazard Rating of 3 (Toxic) or 4 (Highly Toxic).

IV. Program Responsibilities

In addition to those defined by the University Policy Statement 703, the following individuals assume responsibility for the implementation of this plan as described below:

- A. EHS
 - 1. Developing the written Compressed Gas and Cryogenics Safety Program and revising the program as necessary.
 - 2. Developing and providing a training program on the general safe handling, use, storage, and transportation of compressed gas cylinders.

3. Conducting routine inspections to ensure proper storage and use methods are used.
 4. Assists, advises, and instructs University employees in the care and handling of compressed gas cylinders and gas systems.
- B. Department Supervisor/Principal Investigator (PI)
1. Understanding and complying with the requirements of this program.
 2. Ensuring the proper handling, use, storage, and transportation of compressed gas cylinders according to this program.
 3. Training employees on the job specific safe use, handling, storage, and transportation of compressed gas cylinders.
 4. Contact EHS if assistance is needed.
- C. Employees
1. Complete training as necessary.
 2. Comply with the procedures outlined in this program.
 3. Inform their supervisor of any problems, defective equipment, or lack of proper storage space for compressed gas cylinders used by them.

V. Training

All employees affected by this program shall be trained in compressed gas cylinder safety. The training shall include:

- A. Identify the hazards associated with compressed gases.
- B. Identify requirements for cylinder marking.
- C. Identify proper storage precautions for gas cylinders.
- D. Identify general safety precautions for using and handling cylinders.
- E. Identify techniques for leak detection.
- F. Identify requirements for safely transporting containers and cylinders.
- G. Identify safe handling techniques for poison inhalation hazard materials and cryogenic gas containers.

VI. Personal Protective Equipment

- A. Face Protection. A face shield shall be worn when there are additional hazards to the face.
- B. Foot Protection. Use closed toe shoes when moving or transporting cylinders for occasional movement of cylinders. Safety toe shoes should be used for frequent movement of compressed gas cylinders.
- C. Gloves and Clothing. To protect against frostbite, corrosives, and pinch points.
- D. Safety Glasses or Goggles. Use especially when connecting and disconnecting gas regulators and lines.

VII. Labeling

Compressed gas cylinders shall be legibly marked for the purpose of identifying the gas content with either the chemical or the trade name of the gas. Such marking shall be by means of stenciling, stamping, or labeling, and shall not be readily removable. Whenever practical, the marking shall be located on the shoulder of the cylinder - [OSHA Standard 29 CFR 1910.253 \(b\) \(1\) \(ii\)](#).

- A. A durable label should be provided that cannot be removed from the compressed gas cylinder.
- B. Color-coding is not a reliable means of identification; cylinder colors vary from supplier to supplier, and labels on caps have no identification value because many caps are interchangeable.
- C. Compressed gas cylinders that do not clearly identify the contents by name should not be accepted for use.
- D. 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.

VIII. Safe Handling of Cylinders

All compressed gas cylinders must be properly stored in compliance with OSHA and NFPA requirements. Proper signage is required at compressed gas cylinder storage locations. The following precautions should be taken for the storage of compressed gas cylinders:

- A. Cylinders must be stored in a dry, cool, well-ventilated, secure area or approved designated area.
- B. All cylinders, whether empty or full, must be stored upright and secured by chains, straps, or in racks to prevent them from falling.
- C. Segregate cylinders by contents. For example, flammable gases must be stored separately from oxidizing gases by 20 feet or a 5-foot high, one-hour fire-rated wall.
- D. Prevent smoking or open flames in oxidizer or flammable gas storage areas.
- E. Do not expose cylinders to corrosive materials such as corrosive gas or other combustible materials.
- F. Segregate full and empty cylinders, use “first in first out” inventory control method.
- G. Store cylinders away from heavily traveled areas and emergency exits.
- H. Provide adequate access for cylinder handling and material handling carts.
- I. Visually inspect stored cylinders on a routine basis, look for indication of leakage or problems. If an issue is observed, do not use the cylinder and contact the supplier for an exchange.
- J. All cylinder storage areas, outside or inside, shall be protected from extreme heat and cold and from access by unauthorized personnel. Prevent indoor or outdoor temperatures from exceeding 125 °F or 52 °C.
- K. Compressed gas cylinders must be transported with protective caps in place. Do not lift the cylinder by the protective cap.
- L. Never allow oil, greases and other readily combustible substances to come in contact with oxygen cylinders, valves, regulators, and fittings.

IX. Storage of Cylinders

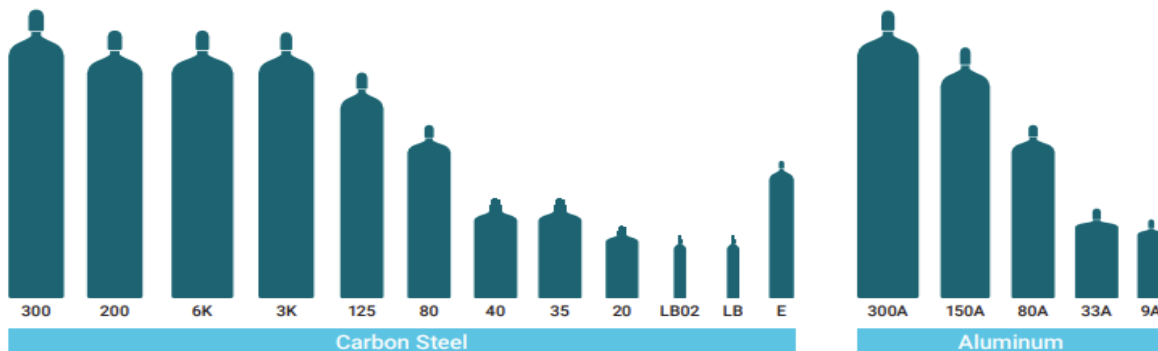
- A. Cylinders must be secured in one or more of the following ways:
 - 1. At a minimum, cylinders must be secured at approximately 2/3 the height of the cylinder, secured above the midpoint, but below the shoulder. When cylinders are secured by a chain or strap, the preferable method is to secure them in two locations – one strap or

chain 2/3 the height of the cylinder and another strap or chain 1/3 up from the bottom of the cylinder.

2. By a noncombustible rack, framework, cabinet, secured welding cart, or other substantial assembly that prevents the cylinder from falling. Cylinder carts are for temporary use only.
 3. By a noncombustible, two-point restraint system (e.g., chains) that secures the cylinder.
 4. Where multiple cylinders are stored and space is limited, nesting of cylinders may be allowed up to 3 cylinders. Storage of parallel cylinders with a single chain or strap is permitted up to 2 cylinders.
- B. Compressed gas cylinders must be protected from sources of heat while stored in a well-protected, well-ventilated, and dry location away from highly combustible materials.
- C. Do not secure cylinders to any form of piping, plumbing, or conduit.

X. Cylinder Sizes

When purchasing hazardous gases, consider that the initial purchase cost per cubic foot may be lower in full sized cylinders. However, the overall cost of experimental setup which may require local ventilation, gas cabinets, or stainless-steel piping and purging systems may offset the apparent saving from buying hazardous gases in full sized cylinders.



XI. Regulators

- A. Use regulators that meet the requirements of UL 252 where applicable. Regulators reduce high pressure gas on a cylinder or process line to a lower usable level. Regulators provide additional safety measures by preventing fire/explosions, chemical or cold burns, poisoning and system over-pressurization. Regulators must be appropriate for the pressure range of the work being performed and ideally should have a pressure rating twice as high as the operating pressure.
- B. Before attaching a regulator, be sure to check with the cylinder manufacturer to understand the CGA connection of the cylinder. There are

also either RH (right-hand) or LH (left-hand) threads. LH threads are reversed instead of typical right-hand threads. Ensure you know which thread is applicable to your gas cylinders since it may be reversed when you loosen or tighten a connection. For example, all AirGas brand toxic, poisonous, corrosive and flammable gas cylinders will have left-hand thread. This will carry over to mixtures as well. When the mixture qualifies for one of these designations based on percentages of the minor components it will become a LH connection.

XII. Tubing and Piping Connections

Safety considerations include materials of construction to ensure chemical compatibility and never use any regulator for gases other than those for which it is intended. Hazardous gases must be dispensed using systems that are properly cleaned and compatible with the gas in use. “Burst pressure” of tubing and piping must be twice the maximum pressure on the second stage regulator. Exceptions as reviewed and approved by UNC Charlotte EHS may be made for short sections of tubing when it and the compressed gas cylinder are completely enclosed in a fume hood and low pressures and flow rates are used. When planning for a compressed gas system, please take the following items into account:

- A. Always clamp flexible tubing connections. Use a clamp approved for the maximum allowable pressure that the connection is subject to. Never use wire, which may cut the flexible tubing.
- B. Always leak-check tubing or piping connections when using hazardous gases. Leak check procedures are to be identified in a lab specific SOP. EHS has select [Chemical SOP](#) templates listed on our website.
- C. Appropriately rated flexible lines are suitable for manifold/cylinder connections.
- D. Highly toxic, pyrophoric, and flammable gases shall be piped using orbital weld stainless steel tubing except as follows:
 - 1. All tubing is contained within an exhausted enclosure such as a fume hood or double walled piping.
 - 2. Such tubing shall be installed below ceilings with appropriate gas sensors. I.e. specific to the specialty gas, connected to an automatic shut-down system for such gas flow if required under permit review.
- E. Most flexible tubing deteriorates with age or exposure to chemicals or UV light. Replace old flexible tubing before it deteriorates.

- F. Secure and support tubing or piping to keep it in place and to prevent "whipping" if a connection fails under pressure.
- G. Shut-off valves at both ends of the gas tubing using gas shutoff valves specific to the gas type and capable of handling estimated maximum gas pressure of such gas cylinder should be considered.
- H. Teflon tape should never be used on cylinder connections or tube-fitting connections. Use Teflon tape only on pipe threads where the seal is made at the threads. All other connections have metal to metal face seals or gasket seals.
- I. Use "hard" compatible piping (such as copper and stainless-steel tubing) whenever possible (as opposed to flexible or plastic tubing). Never use cast iron pipe or fittings.
- J. When flexible tubing must be used, select tubing compatible with the chemical and pressure properties of the gas being used in the system. Do not use flexible tubing for toxic, highly toxic or pyrophoric gases. Flexible tubing should only be used within "line of sight." Do not run flexible tubing through walls, ceiling spaces, doorways, or other non-visible pathways if chafing is likely to occur.

XIII. Valves

Check valves are mechanical valves that permit gases and liquids to flow in only one direction, preventing process flow from reversing. Common types of valves include check, ball, disk, butterfly, gate, diaphragm, needle, and solenoid. Valves can be made of plastic, stainless steel or other material. Valves serve unique requirements, so it is important to select the specific type of valve for your operation. Precautions to consider while using valves are:

- A. Inspect the valve for damage and foreign materials before connecting to the cylinder.
- B. Never drag, lift, or move a cylinder using the valve or the hand wheel as a handle.
- C. Never lubricate valves or their connections.
- D. Never move cylinders without the transport cap installed.
- E. Never tamper with regulatory or attempt to tighten or loosen the valve into or out of the cylinder.

- F. Never use a damaged valve where integrity may have been affected. Discontinue using a valve that operates abnormally, i.e., becomes noisy or progressively harder to operate.
- G. Never use an automatic operator, adapter, wrenches, or other tools to obtain a mechanical advantage on hand wheel-operated valves without reviewing all safety requirements.
- H. Open valves slowly to control pressure surges and heat of compression.
- I. Use the cylinder valve to regulate flow or pressure.

A rupture disk is a non-reclosing pressure relief device that protects a pressure vessel like a compressed gas cylinder from over pressurization or potentially damaging vacuum conditions. A rupture disc (also known as a bursting disc), is designed to provide a leak-tight seal within a pipe or vessel, until the internal pressure rises to a predetermined level. At that point the rupture disc bursts, preventing damage to the equipment from overpressure.

XIV. Types of Compressed Gases

The types of compressed gas can be divided into three categories, each with unique characteristics:

- A. Liquefied Gas can become liquid at normal temperatures when they are inside a cylinder under pressure. When gas is removed from the cylinder, enough liquid evaporates to replace it, keeping the pressure in the cylinder constant. Common examples include anhydrous ammonia, chlorine, propane, nitrous oxide, and carbon dioxide.
- B. Non-Liquefied Gas is also a compressed, pressurized or permanent gas. These gases do not become liquid when they are compressed at normal temperatures or even very high pressures. Common examples are oxygen, nitrogen, helium, and argon.
- C. Dissolved Gas can also be compressed. A common example of dissolved gas is acetylene. Care should be taken when using acetylene or welding. Consult your supervisor before using acetylene.

XV. Flammable And Pyrophoric Gases

Flammable gases such as propane, hydrogen, and acetylene should have a red label. However, the color itself is not a good indicator of flammability as different distributors may use different colored cylinders for the same gas. Check the label for flammability. More information regarding flammable gases is available in Appendix A.

- A. The flammable range of a gas, including all concentrations in air between the Lower Flammable Limit (LFL) and the Upper Flammable Limit (UFL) needs to be recognized. For example, the flammable range for hydrogen is an LFL = 4% and an UFL = 75%.
- B. The auto-ignition temperature is the minimum temperature that gas and its vapors can spontaneously ignite in air. Examples include Silane or Diborane.
- C. Flammable gas must be segregated from oxidizers and shall comply with [NCFC Chapter 58](#).
- D. Pyrophoric gas (arsine, silane, phosgene, diborane, etc.) cylinders should be stored in a suitable exhausted location in compliance with [NCFC Chapter 64](#) with gas detection as specified in this program. If a hazardous gas cylinder develops a leak, evacuate and restrict area access.

The following are requirements for storage of flammable gas:

- A. All compressed gas cylinders shall be stored in an upright position.
- B. All flammable gas cylinders, full or empty, shall be handled in the same manner.
- C. Store empty cylinders separately from full cylinders.
- D. Always use non-sparking tools on compressed gas cylinders.
- E. Compressed flammable gas cylinders shall not be exposed to dampness, salt, corrosive chemicals or fumes that could damage the cylinders or valve-protective caps.
- F. Compressed flammable gas cylinders should not be placed where they could become a part of an electrical circuit.
- G. Compressed flammable gas cylinders, whether full or partially full, shall not be exposed to or heated by devices that could raise the temperatures above 125 °F (52 °C).
- H. Leaking, damaged, or corroded compressed flammable gas cylinders should be removed from service.
- I. Signs should be posted in areas containing flammable gases communicating that smoking or the use of open flame, or both, is prohibited within 25 feet of the storage or use area perimeter.

- J. Static-producing equipment located in flammable gas areas shall be grounded.
- K. Cylinders stored outside:
 - 1. Shall not be placed on the ground (earth) or on surfaces where water can accumulate.
 - 2. Storage areas shall be kept clear of dry vegetation and combustible materials for a minimum distance of 15 feet.
 - 3. Storage areas shall be permitted to be covered with canopies of noncombustible construction.
 - 4. Storage areas shall be provided with physical protection from vehicle damage.
 - 5. The cylinders should not be stored within 10 ft of windows, doors, or other openings nor shall they be stored within 50 feet of ventilation intakes.

XVI. Gas Monitoring and Detection

Use of flammable and highly toxic compressed gases, as defined in this guideline, that are not considered a closed system, must be used within ventilated enclosures such as a laboratory hood or glove box, or the use of real time gas detection may be required.

Exception: Acetylene may be used in designated hot work areas without the use of real time gas detection. However, whenever mobile units are carried into confined spaces, gas monitoring for flammable gases and oxygen must be conducted as required under the [UNC Charlotte Confined Space Program](#).

Gas detection will be installed at the storage location (typically within a gas cabinet) and within the room conveying the flammable gas unless the tubing used to convey the gas from its storage location to the point of use is continuous non-combustible tubing (orbital welds only unless a variance is granted, no fittings), or all fittings are contained within a manifold equipped with local exhaust ventilation, that has been leak checked. Gas detection within the room itself, if required, should be placed at a location likely to detect any leakage such as near an air return. Flammable gas detection shall comply with [NCFC Chapters 53](#) and [58](#) while toxic gas detection must comply with [NCFC 6004.2.2.10](#). Gas detection systems should be set to alarm as follows:

- A. Gas release alarm (TLV level for toxic gases and 25% of LEL for flammable gases)- Activate building fire alarm system which should include at least horns and strobes.

- B. Gas warning alarm (1/2 of TLV for toxics and 5% of LEL for flammables) – send trouble signal to fire alarm panel and/or UNC Charlotte Police to contact lab or EHS on call representative to investigate.
- C. Gas monitor trouble alarm, same as letter B above.

Any maintenance or repair on the monitoring device should be only performed by the manufacturer or manufacturer's representative using manufacturer specific replacement parts, or by personnel authorized and trained to conduct maintenance and repair by either department management or EHS. Most oxygen monitoring devices require minimal periodic maintenance. Follow the manufacturer's recommendations on calibration, maintenance, and sensor replacement. The installation, testing and maintenance costs for oxygen monitors and associated engineering controls shall be the responsibility of the department or responsibility center using cryogenics or asphyxiant gases.

XVII. Cryogenics

All cryogenic liquids should be used with caution due to the potential for skin or eye damage due to the low temperature, and the hazards associated with pressure buildups in enclosed piping or containers. Special hand/arm protection includes the use of cryogenic gloves; these gloves should be loose fitted and are designed to protect human tissue from cold burns.

Personal Protective Equipment (PPE) includes:

- A. A full-face shield
- B. Safety goggles
- C. Cryogenic apron
- D. Lab coat
- E. Clothing that prevents the absorption of liquids such as thick sweaters, jackets and pants with cuffs for transferring cryogenic fluids.

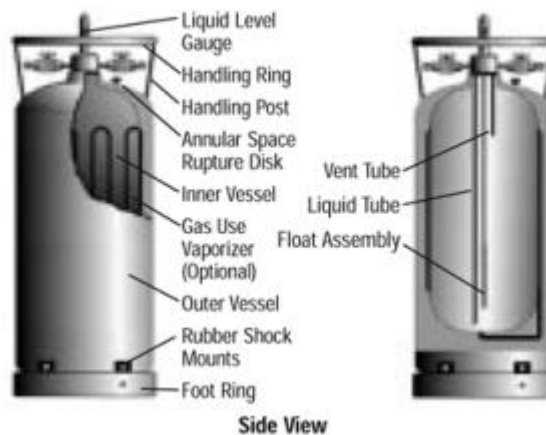
Portable containers should only be used where there is sufficient ventilation. Do not place containers in a closet or other enclosed space (e.g., elevators) where there is little or no ventilation supply to the area. The buildup of inert gas in such an area could generate an oxygen deficient atmosphere.

Special vacuum jacket containers with loose fitting lids should be used to handle small quantities. Vacuum jacketed containers provided by the gas supplier will have overpressure relief devices in place.

Any space where cryogenic fluids may accumulate (consider leakage into enclosed equipment) must be vented or protected by overpressure relief devices.

Tremendous pressures can result in enclosed spaces as the liquid converts to gas. For example, one cubic centimeter of liquid nitrogen will expand to 700 times this volume as it converts or warms to its gaseous state.

Containers that will be filled with cryogenic liquids should be filled slowly to avoid splashing.



Cryogenic containers showing evidence of loss of vacuum in their outer jacket – ice buildup on the outside of the container – should not be accepted from the gas supplier. Contact with air, or gases with a higher boiling point, can cause an ice plug in a cryogenic container.

XVIII. Dewar Safety

Dewars usually have nitrogen as its common content. Contact of liquid nitrogen or any extremely cold gas with the skin or eyes may cause serious freezing (frostbite) injury.

Always protect your hands when working with liquid nitrogen. Handle Liquid Nitrogen carefully, the extremely low temperature can freeze human flesh very rapidly. When spilled on a surface the liquid tends to cover it completely and immediately, cooling a large area.

The gas evaporating from the liquid is also 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.

Never allow any unprotected skin to touch objects cooled by liquid nitrogen:

- A. Such objects may stick fast to the skin and tear the flesh when you attempt to free yourself.
- B. Use tongs, preferably with insulated handles, to withdraw objects immersed in the liquid, and handle the object carefully.

When working with cryogenic dewars, consider the following regarding PPE:

- A. Protect your eyes with a full-face shield and safety goggles (safety glasses without side shields do not give adequate protection).
- B. Always wear cryogenic gloves when handling anything that is, or may have been, in immediate contact with liquid nitrogen. The gloves should fit loosely, so that they can be thrown off quickly if liquid should splash into them.
- C. When handling liquid in open containers, it is advisable to wear high-top shoes.
- D. Long pants (which should be cuffless if possible) should be worn outside the shoes.
- E. 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.

Approved Containers for Cryogenic Liquids

- A. Cryogenic containers are specifically designed and made of materials that can withstand the rapid changes and extreme temperature differences encountered in working with liquid nitrogen. Even these special containers should be filled slowly to minimize the internal stresses that occur when any material is cooled. Excessive internal stress can damage the container.
- B. Do not ever cover or plug the entrance opening of any liquid nitrogen dewar. Do not use any stopper or other device that would interfere with venting of gas.
- C. These cryogenic liquid containers are generally designed to operate with little or no internal pressure. Inadequate venting can result in excessive gas pressure which could damage or burst the container.
- D. Use only the loose-fitting neck tube core supplied or one of the approved accessories for closing the neck tube. Check the unit periodically to be sure that venting is not restricted by accumulated ice or frost.



Proper Transfer Equipment

- A. Use a phase separator or special filling funnel to prevent splashing and spilling when transferring liquid nitrogen into or from a dewar. The top of the funnel should be partly covered to reduce splashing.
- B. Use only small, easily handled dewars for pouring liquid. For the larger, heavier containers, use a cryogenic liquid withdrawal device to transfer liquid from one container to another. Be sure to follow the instructions supplied with the withdrawal device.
- C. When liquid cylinders or other large storage containers are used for filling, follow the instructions supplied with those units and their accessories.
- D. Avoid overfilling containers. Filling above the bottom of the neck tube (or specified maximum level) can result in overflow and spillage of liquid when the neck tube core or cover is placed in the opening.
- E. Never use hollow rods or tubes as dipsticks. When a warm tube is inserted into liquid nitrogen, liquid will spout from the bottom of the tube due to gasification and rapid expansion of liquid inside the tube. Wooden or solid metal dipsticks are recommended; avoid using plastics that may become very brittle at cryogenic temperatures which then become prone to shatter like a fragile piece of glass.

Nitrogen gas can cause suffocation without warning. Store and use liquid nitrogen only in a well-ventilated place. As the liquid evaporates, the resulting gas tends to displace the normal air from the area. In closed areas, excessive amounts of nitrogen gas reduces the concentration of oxygen and can result in asphyxiation. Because nitrogen gas is colorless, odorless and tasteless, it cannot be detected by the human senses and will be breathed as if it were air. Breathing an atmosphere that contains less than 18 percent oxygen can cause dizziness and quickly result in unconsciousness and death.

Proper Disposal:

- A. Do not pour the liquid on the ground.
- B. Never dispose of liquid nitrogen in confined areas or places where others may enter.
- C. Disposal of liquid nitrogen should be done outdoors in a safe place. Pour the liquid slowly on gravel or bare earth where it can evaporate without causing damage. The cloudy vapor that appears when liquid nitrogen is exposed to the air is condensed moisture, not the gas itself. The gas actually causes condensation and freezing is completely invisible.

First Aid

- A. If a person seems to become dizzy or loses consciousness while working with liquid nitrogen, move to a well-ventilated area immediately. If breathing has stopped, contact 911 or 704-687-2200 for campus police. Immediately and apply artificial respiration. If breathing is difficult, give oxygen. Keep them warm and resting.
- B. If exposed to liquid or cold gas, restore tissue to normal body temperature 98.6°F (37°C) as rapidly as possible, followed by protection of the injured tissue from further damage and infection. Remove or loosen clothing that may constrict blood circulation to the frozen area. Call a physician. Rapid warming of the affected part is best achieved by using water at 108°F(42°C).
- C. Under no circumstances should the water be over 112 °F(44°C), nor should the frozen part be rubbed either before or after rewarming. The patient should neither smoke nor drink alcohol.

Handling Liquid Nitrogen Dewars

- A. Do not place these units in closed vehicles where the nitrogen gas that is continuously vented from the unit can accumulate. (Unless a specifically manufactured dewar is obtained and verified by UNC Charlotte EHS).
- B. Prevent spillage of liquids and damage to unit by securing it in the upright position so that it cannot be tipped over. Protect the unit from severe jolting and impact that could cause damage, especially to the vacuum seal.
- C. Dropping the container, allowing it to fall over on its side, or subjecting it to sharp impact or severe vibration can result in partial or complete loss of vacuum. To protect the vacuum insulation system, handle containers carefully.
- D. Do not "walk", roll or drag these units across a floor. Use a dolly or handcart when moving containers, especially the larger portable refrigerators. Large units are heavy enough to cause personal injury or damage to equipment if proper lifting and handling techniques are not used.
- E. Always keep unit upright except when pouring liquid from dewars specifically designed for that purpose.

- F. Rough handling can cause serious damage to dewars and refrigerators.
- G. Tipping the container or laying it on its side can cause spillage of liquid nitrogen. It may also damage the container, and any materials stored in it.
- H. When transporting contents from a liquid nitrogen dewar, maintain adequate ventilation and protect the unit from damage.
- I. Keep the unit clean and dry. Do not store it in wet, dirty areas. Moisture, animal waste, chemicals, strong cleaning agents, and other substances which could promote corrosion should be removed promptly.
- J. Use water or mild detergent for cleaning and dry the surface thoroughly. Do not use strong alkaline or acid cleaners that could damage the finish and corrode the metal shell.

XIX. Compressed Gas Emergencies

Emergencies involving compressed gases are unlikely, provided the recommendations are followed for their correct storage, handling, and use. When problems do arise, they are typically due to:

- A. Fire threatening the cylinder.
- B. Toxic or inert gas leaks.
- C. Unplanned chemical or other reaction.

Most leaks occur at the valve and valve stem fitted on the top of the cylinder. Leakage here is frequently due to dirt in the connection, or damaged connections or washers where required.

Such leaks are easily rectified. Attempt to tighten the connection. If cylinders are involved in any type of emergency, and it's safe to do so, isolate the gas outdoors and away from sparks and heat. In any event all defective cylinders should be clearly labeled and returned to the supplier.

On the UNC Charlotte campus, major spills or release of volatile hazardous materials must be referred to the Campus Police by calling 911 from a campus phone or 704-687-2200 from any phone. Campus Police will contact Charlotte Fire Department (CFD) and the EHS Office. Hazardous Materials Response Team will respond if conditions warrant. For major spills, it is important to immediately leave the area and inform building occupants of the situation.

For additional information, please refer to the [UNC Charlotte Chemical Hygiene Plan](#).

Appendix A General Guidelines for Flammable Gases

The volume of flammable gas in a lab, room or location is restricted by University guidelines and Fire Codes. EHS should be contacted regarding any questions or for additional guidance.

The volume of flammable gas shall be kept to the minimum necessary for the work being done. Delivery for immediate use should be used where possible. The maximum internal volume (water volume) of all cylinders in each of the listed classifications, in use in the laboratory work area or single fire area, shall comply with the following based on internal cylinder volume at 70 °F (21 °C).

For a laboratory work area of 500 ft² or less, the internal cylinder volume equals 6.0 ft³ or approximately three (3) “K” (9.25 inch diameter, 60 inch height) sized cylinders.

For a laboratory work area greater than 500 ft², the internal cylinder volume is 0.012 ft³ per ft² lab work area, but not to exceed the maximum cubic feet of gas from the chart below (approximately five (5) “K” sized cylinders for flammable gas).

Material	Storage (Cubic Feet)	Use-Closed System (Cubic Feet)	Use-Open System (Cubic Feet)
Oxidizing Gas	1,500	1,500	N/A
Flammable Gas	1,000	1,000	N/A
Pyrophoric Gas	50	10	N/A

The maximum quantity of lecture bottles in a single fire control area should not exceed 20. UNC Charlotte strongly discourages the use of any non-returnable, non-refillable compressed gas cylinders or lecture bottles.

Flammable gases should be separated by 20 feet (6.1 m) from all pyrophoric, oxidizing and corrosive gases except as follows:

- A. The 20 feet distance shall be reduced without limit when separated by a barrier of noncombustible materials at least 5 feet (1.5 m) high that has a fire resistance rating of at least 30 minutes.
- B. The 20-foot distance shall be reduced to 5 feet where one of the gases is enclosed in a gas cabinet or without limit where both gases are enclosed in a gas cabinet.
- C. Cylinders without pressure-relief devices shall be stored separately from flammable and pyrophoric gases with pressure-relief devices.

Appendix B G Cabinet Considerations

Gas cabinets are required for the use of any amount of toxic, highly toxic, corrosive, flammable or pyrophoric gas at UNC Charlotte except where quantities of toxic, corrosives or flammable gases are in cylinder sizes of 40 cubic feet or smaller and where quantities of highly toxic or pyrophoric gases are lecture bottle size only.

The gas cabinet is designed to contain and exhaust to a safe location any accidental releases and protect the gas cylinder from physical damage. A gas cabinet may also be used when the maximum allowable quantity of a gas in a control area exceeds Fire Code limits. In this case, a gas cabinet may allow a doubling of the allowable quantity of gas in use.

Selection

- A. Gas cabinets are often manufactured for the highest level of hazard, need for purity and automation. The installer or user must ensure that the gas cabinet and its ventilation system comply with all applicable standards from OSHA, NFPA, and the ICC.

Gas Panel

- A. The gas panel or manifold is an assembly of gas piping, regulators, and devices designed to safely dispense gas at controlled flow rates. The gas panel is constructed with mechanical fittings, all of which must be kept within the exhausted gas cabinet enclosure. There can be no mechanical connections on systems containing hazardous gases unless they are in an exhausted enclosure except for purge cylinders.

Local Exhaust Ventilation

- A. Gas cabinets will require connection to an exhaust system. The manufacturer determines the amount of local exhaust ventilation required to operate the cabinet. [Per Chapter 60 of the NCFC](#), the minimum average face velocity shall not be less than 200 feet per minute (fpm) or 150 fpm at any point across the access port. For a single cylinder cabinet, this usually equates to a volumetric flow rate of 150 cubic feet per minute (cfm).
- B. Most manufacturers will require at least 200 cfm and some may require 300 cfm, or more, depending on the cabinet size. Valve manifold boxes, purifier cabinets, and equipment panel cabinets should be exhausted to four to five air changes per minute.

- C. The ductwork materials used must be compatible with the intended gases (e.g., galvanized steel versus stainless steel) and should not be made from a combustible material.
- D. The duct installation should include an exhaust controlling device, preferably a blast gate. The blast gate should be located as far away from the cabinet as possible while still being before any upstream branch within the same workspace so that it can be easily accessed. Refer to NFPA 92.
- E. The standard size exhaust connection from a gas cabinet is six inches. The exhaust air shall not be re-circulated into occupied spaces but rather exhausted to the roof in a manner protective of both people working on the roof and those walking nearby. In addition, for toxic and highly toxic gases, a calculation will need to be performed to determine if, in a realistic worst-case release of gas, the concentration of the gas is less than $\frac{1}{2}$ the immediately dangerous to life and health (IDLH) concentration. These requirements may drive the need for an air-scrubbing device and/or restricted flow orifice (see Treatment Systems). Furthermore, the exhaust shall not be located such that it could result in re-entrainment of the contaminant into occupied spaces through doors, windows, or HVAC air intakes.
- F. Cabinet exhaust inlet and outlet shall be designed for good sweep through the entire volume. The inlet louver should have adjustability to aid in balancing the exhaust and achieving required static pressure in the cabinet and duct.

Gas Cabinet Installation

- A. After a gas cabinet is selected, EHS is available for consultation if needed.

Location

- A. Gas cabinets for hazardous gases should not be installed outdoors, unless physically secured behind locked fencing or walls and never near a public way. Unless under direct control of users, gas cabinet areas should be limited to authorized employees only. Gas cabinets cannot be stored in hallways used for exit access. Avoid placing cabinets in any heavy traffic areas which would restrict gas cylinder changes.

Treatment Systems

- A. For toxic and highly toxic gases, a treatment system will be installed to handle an accidental release of a full cylinder of gas and reduce the maximum allowable discharge concentrations to one half IDLH concentrations at the point of discharge to atmosphere. If the cylinder is

equipped with a restrictive flow orifice (RFO), the release rate will be calculated by the maximum flow from the valve as determined by the manufacturer. If not equipped with an RFO, release rate will be considered 5 minutes for non-liquified gases and 30 minutes for a liquified gas.

- B. For toxic gases, a treatment system is not required when an approved gas detection system and approved automatic-closing fail-safe valve is located immediately adjacent to the cylinder valve.

Purge and Vacuum Venturi Vent Gas

- A. An inert gas must be supplied to the gas cabinet for toxic, highly toxic and pyrophoric gas panel purging and if present, the vacuum venturi vent. A mixture of 10% Helium/90% Nitrogen is recommended for the purge gas to facilitate leak checking of the system.
- B. The purge gas supply must be at least 85 psi for cycle purging. The venturi vent is used to pull a vacuum on the panel and ensure an inert atmosphere in pyrophoric vent lines. Purge gases cannot be shared between incompatible hazardous gases (e.g., an oxidizer and a flammable). Panel purge gases shall be delivered from a cylinder source and not from house nitrogen or other house gases. Venturi vent gas typically uses a house nitrogen source.

Automatic Sprinkler

- A. A gas cabinet containing hazardous gas, located in an occupancy area, must have fire suppression and detection in the form of a wax coated sprinkler head to be connected to facility automatic sprinkler system. This is not required if the gas cabinet is in an approved gas distribution room or outdoors.

Operation

- A. A Standard operating procedure (SOP) must be developed before operation. These must detail the safe operation procedures of the gas cabinet. EHS is available for consultation if needed. At a minimum, these procedures shall address the following:
 - 1. Installation, removal, and securing gas cylinders inside the cabinet.
 - 2. Maintenance requirements, including calibration of gas detection equipment and ventilation checks.
 - 3. Purging of the manifold.
 - 4. Response to alarm activation.

Controller

- A. To automatically monitor and control the operation of the gas cabinet, a controller is needed. The controller is normally anchored to the top of the cabinet and comes with a standard set of inputs and outputs. Controllers must have an emergency shutoff button, a local audible alarm, a local visual alarm, and pneumatic connections for input and output for emergency shut off valve control.
- B. Typical controller sensors and shutdowns include:
 - 1. Excess Flow
 - 2. Exhaust Fail
 - 3. Fire Detection
 - 4. Gas Detector Alarm
 - 5. Gas Detector Warning
 - 6. High Delivery Pressure

Pneumatic Gas

- A. For operation of panel automatic valves - typically 75 psi. Use inert gas in flammable and pyrophoric gas cabinets.