WAKE FOREST
UNIVERSITY

Compressed Gas and Cryogenic Safety

February 2023

1. Compressed Gas Safety and Operation

This program covers the proper use of compressed gases, compressed gas cylinders and related equipment.

Gases drawn from cylinders are usually characterized as:

- ➢ Permanent gases have boiling points of -150 °F or lower and cannot be liquefied at room temperature no matter how high the pressure. Examples include oxygen, nitrogen, and helium.
- ➢ Liquid gas liquefy at temperatures of -130 °F or higher at one atmosphere, but can be liquefied and maintained as liquids at higher pressures. Examples include propane, chlorine, and butane. Carbon dioxide is included in this category, but becomes a solid rather than a liquid.
- ➢ Dissolved gases in common use such as acetylene dissolved in acetone.

Refer to the Safety Data Sheets (SDS) for the hazards associated with the specific gas. The Occupational Health and Safety Administration (OSHA) has specific standards for a number of compressed gases, including acetylene, hydrogen and oxygen.

1.1 General Requirements

Improper use, handling, and storage of compressed air, gases, or related equipment can result in serious injury or death, as well as extensive property damage.

Visual inspection of equipment, including portable cylinders is required to ensure equipment is in safe operating condition prior to each use. Never utilize cylinders without first obtaining the proper equipment to use, handle, or store cylinders correctly.

1.2 Compressed Air Used in Cleaning

1.2.1 Air Nozzles

When used for cleaning, the compressed air equipment (air nozzle) must reduce the outlet (working) air pressure to less than 30 pounds square inch (psi) at the discharge tip. This reduction can be done with nozzles and tips designed for this purpose.

NOTE: Users must not remove, damage, cover (i.e., tape), replace or in any way alter the equipment provided for this purpose. Nozzles that have been altered or "home-made" are not approved and will not be used.

1.2.2 Chip Protection

In-line chip protection will be used when airlines are connected directly to a compressed air system. This does not mean that the supply air or line pressure be reduced to 30 psi

as long as the static (dead head) pressure exiting the nozzle when restricted does not exceed the mandatory maximum 30psi.

1.2.3 Eye Protection

To prevent eye injury, employees using compressed air should, at a minimum, wear appropriate safety glasses with side shields at all times.

1.3 Air Receivers (Portable Air Tanks and Air Compressor Tanks)

1.3.1 Installation

Air receivers must be installed per the ASME Boiler and Pressure Vessel Code, Section VII. Air receivers must be installed to ensure accessibility for maintenance and draining. Valves, indicating devices, and controlling devices are to be constructed, located, and installed so that they cannot be readily rendered inoperable.

1.3.2 Drains

To provide for removal of accumulated water and oil, a drain pipe and valve must be installed at the lowest point of every air receiver. The drain valve must be opened frequently in order to drain the air receiver of accumulated water and oil.

1.3.3 Pressure Gauge and Safe Pressure Relief

Every air receiver must be equipped with a pressure gauge which is readily visible and with spring loaded safety valves which prevents the receiver from exceeding the maximum allowable working pressure by more than 10 percent.

1.3.4 Maintenance and Testing

All safety valves must be tested on a regular basis to ensure they are in good operating condition. A record of the test result should be maintained in the Facilities and Campus Services (F&CS) Preventative Maintenance system.

1.4 Compressed Gas Portable Cylinders

Compressed gas cylinders require special handling, using, and storing procedures. This procedure describes how to handle and store compressed gas cylinders properly on the WFU campus. This procedure is a general guideline and may not be applicable to all situations. Contact the Environmental Health and Safety Office for additional information or assistance.

Approval

All portable cylinders used for the storage and shipment of compressed gases must be constructed and maintained in accordance with the regulations of the U.S. Department of Transportation, 49 CFR Parts 171-179.

Markings

Compressed gas cylinders must be legibly marked for the purpose of identifying the gas content with either the chemical or the trade name of the gas. The marking will be by stenciled, stamped or labeled, and not be readily removable. Whenever practical, the marking will be located on the shoulder of the cylinder. This method conforms to the American National Standard Method for Marking Portable Compressed Gas Containers to Identify the Material Contained, ANSI Z48.1-1954.

Connections

Compressed gas cylinders will be equipped with connections complying with the American National Standard Compressed Gas Cylinder Valve Outlet and Inlet Connections, ANSI B57.1-1965.

Valve Covers

All cylinders with a water weight capacity of over 30 pounds (13.6 kg) will be equipped with a means of connecting a valve protection cap or with a collar or recess to protect the valve.

1.4.1 Handling Compressed Gas Cylinders

- All cylinders used on campus must be clearly labeled. The label must include contents, concentrations, hazard classifications, safety precautions and the manufacturer. The label can either be attached or stenciled onto the cylinder. Do not remove manufacturer applied labels or accept a cylinder if the contents are not clearly identified. Do not rely on color coding, because it is not a standardized labeling system.
- All cylinders must be in good condition with an operable valve or regulator. Cylinders without valves and regulators should be capped.
- All cylinders must be transported using a hand truck or cart equipped with a chain or belt for securing the cylinder. In certain situations, cylinders may be rolled on their bottom edge. Make sure the protective cap covers the cylinder valve. Never move a cylinder with the regulator attached. Do not move cylinders by rolling, carrying, sliding, or dragging them across the floor. Do not transport oxygen and combustible gases at the same time.
- Cylinders will not be dropped or be allowed to strike each other violently.
- Safety devices in valves or on cylinders will not be tampered with.
- Cylinders will always be secured to prevent them falling over. Chains or a clamp-plus-strap assembly are the most common methods of keeping cylinders upright. Please ensure the chain or strap is attached high enough to prevent the cylinder from falling over.
- Cylinders will always be considered full and will be handled carefully.

1.4.2 Using Compressed Gas Cylinders

- Unless the cylinder valve is protected by a recess in the head, the metal cap will be kept in place to protect the valve when the cylinder is not connected for use. A blow on an unprotected valve might cause high pressure gas to escape.
- The threads on a regulator will be identical to those on the cylinder valve outlet. Connections that do not fit will not be forced on.
- Always inspect all parts of a compressed gas cylinder before use. A soapy water solution may be used to check for leaks.
- Cylinder valves will be opened slowly. Cylinders without handwheel valves will be opened with a spindle key, special wrench, or other tool provided or approved by the gas supplier.
- Cylinders will never be used without a pressure-reducing regulator attached to the cylinder valve except where cylinders are attached to a manifold – in which case the regulator will be attached to the manifold header.
- Before making connection to a cylinder valve outlet, the valve will be slightly opened for an instant to clear the opening of particles of dust or dirt. The valve and opening will always be pointed away from the body and not toward anyone else. NOTE: Fuel gas cylinder valves will not be slightly opened for an instant near other welding work, sparks, open flames, or other possible sources of ignition.
- Regulators and pressure gauges will be used only with gases for which they are designed and intended. Do not attempt to repair or alter cylinders, valves, or attachments. This will be done only by the manufacturer.
- Oil or grease will never be used as a lubricant on valves or attachments of oxygen cylinders. Oxygen cylinders and fittings will be kept away from oil and grease such cylinders or apparatus will not be handled with oily hands, gloves, or clothing.
- Never use oxygen as a substitute for compressed air in pneumatic tools, in oil preheating burners, to start internal combustion engines, or to dust clothing. It will be used only for the purpose for which it is intended.
- Cylinders will never be brought into confined spaces or unventilated rooms.
- DO NOT use or compress Acetylene in a free state at pressure higher than 15 pounds per square inch.
- Cylinders will never be filled or gases attempted to be mixed on campus.
- Never completely empty the cylinder; always leave a residual gas pressure of 30psi.
- Before a regulator is removed, the cylinder valve will be closed and the gas released from the regulator.
- Unless the cylinder valve has first been closed tightly, no attempt will be made to stop a leak between the cylinder and the regulator by tightening the union nut.

1.4.3 Leaking Compressed Gas Cylinder

If a leak occurs in a fuel gas cylinder it will be taken out of use immediately and handled as follows:

- The valve will be closed and the cylinder taken outdoors well away from any ignition source. The cylinder will be tagged (Do Not Use, No Smoking, No Ignition Source) and the supplier notified.
- A regulator attached to the valve may be used temporarily to stop a leak through the valve seat.
- If the gases are toxic, the cylinder should be removed to an isolated, well-ventilated area, but only if this is possible while maintaining personal safety. It may be necessary to call campus police for a general evacuation of the building and have the cylinder approached only by trained emergency response personnel wearing protective apparel and self-contained breathing apparatus (SCBA).

1.4.4 Storing Compressed Gas Cylinders

- Storage rooms for cylinders containing flammable gases will be well ventilated to prevent the accumulation of explosive concentrations of gas; no source of ignition will be permitted; smoking will be prohibited.
- Do not store incompatible gases together. Oxygen cylinders will be stored at least 20 feet from gas cylinders or highly combustible materials. If closer, cylinders will be separated by a fire-resistive partition at least 5 feet having a fire resistive rating of at least ½ hour.
- Cylinders will not be stored in temperatures above 125 degrees Fahrenheit or near sources of heat such as radiators/furnaces, or near highly flammable substances like gasoline, oil, or volatile liquids.
- Acetylene and liquefied fuel gas cylinders will be stored with the valve end up.
- Cylinders will not be stored near elevators, gangways, corridors, stairwells, or other places where they can be knocked down or damaged.
- Cylinders stored in the open will be protected from contact with the ground and against weather affects.

2. Cryogenic Materials Operating Procedure and Safety

2.1 Overview of Liquid Nitrogen and other Cryogenic Materials

- Liquid nitrogen is inert, colorless, odorless, non corrosive, nonflammable, and extremely cold.
- Nitrogen makes up the major portion of the atmosphere (78.03% by volume, 75.5% by weight).
- Liquid nitrogen has a boiling point of –320°F (–196°C).
- Cryogenic liquids are liquefied gases that have a normal boiling point below –130°F (–90°C).

Expansion Ratio at 20° Celsius for Common Cryogenic Fluids (Liquid to Gas)			
Cryogenic Liquid	**Liters of Liquid**	**Liters of Gas Produced**	**Cubic Feet of Gas Produced**
Nitrogen	1	696	24.6
Oxygen	1	861	30.4
Helium	1	754	26.6

2.2 Personal Protective Equipment for Liquid Nitrogen or Cryogenics

Eye protection

- When pouring liquid nitrogen from a Dewar, use non-vented chemical goggles.
- When working with liquid nitrogen in an open container or when transferring liquid nitrogen from a pressurized device, use safety glasses and a full-face shield.

Hand Protection

- When working on piping systems with exposed components at cryogenic temperatures, wear loose-fitting gloves made for cryogenic work to assure that skin will not freeze to cold pipes or metal parts.
- Loose-fitting gloves can be thrown off readily if cryogen is spilled into them. Small spills of liquid nitrogen, if not trapped against the skin, will usually evaporate without causing damage.

Body Protection

- ➢ Wear long-sleeved clothing made of non-absorbent material, long pants worn outside boots or over shoes, and an apron when handling large quantities of cryogens.
- ➢ Always wear closed toe shoes.

2.3 Health Effects of Liquid Nitrogen

Asphyxiation

Nitrogen is not poisonous; the air is already about 78% nitrogen (oxygen makes up about 21%, and trace gases the remaining 1%). However, if sufficient liquid nitrogen or other Cryogenic Material vaporizes from a pressurized container into a poorly ventilated space, it can reduce the oxygen concentration to below 20%. Personnel in that space are in a situation immediately dangerous to life and health due to rapid oxygen deprivation. Rapid venting of Cryogenic Material can cause rapid displacement of normal air, leading to a local concentration of nearly 100% nitrogen or other Cryogenic Material.

Burns

Direct contact between skin and Cryogenic Material can cause cold burns and frostbite. Prolonged contact may result in blood clots.

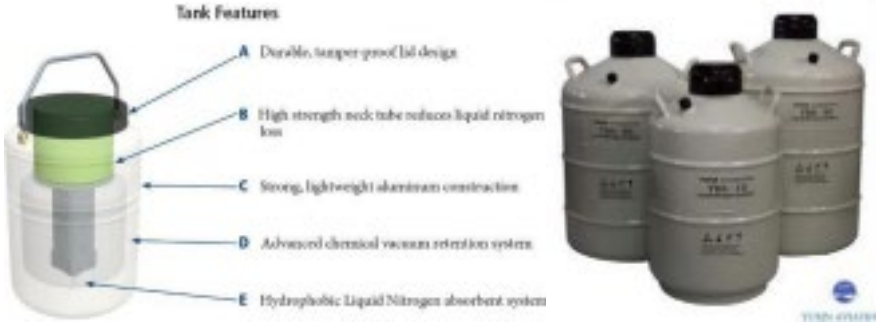
Pressure and Explosions

Large liquid-to-gas ratios can lead to rapid pressure changes as cryogens vaporize. All Cryogenic Materials can condense sufficient moisture from the air, subsequently freezing and blocking the opening of storage Dewars. This can lead to an explosion from the buildup of trapped gases in the container. For example, cryotubes stored in liquid nitrogen may explode when removed from the Dewar.

2.4 Container Types for Liquid Nitrogen or Cryogenic Materials

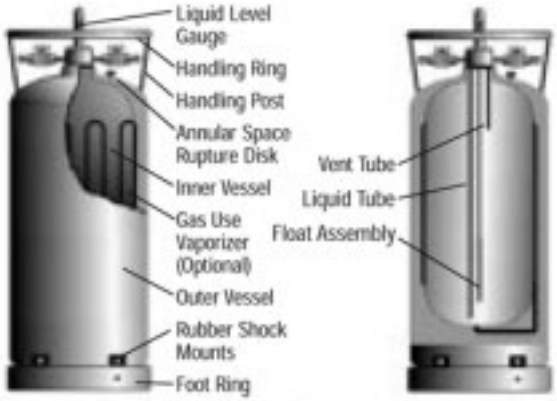
2.4.1 Dewars

A loose-fitting dust cap over the outlet of the neck tubes prevents atmospheric moisture from plugging the neck while allowing gas produced from vaporized liquid to escape. This type of container is normally a non-pressurized container. Five- to 200-liter Dewars are available. Products may be removed from small Dewars by pouring, while larger sizes will require a transfer tube.



2.4.2 Cryogenic Liquid Cylinders

Cryogenic liquid cylinders are insulated, vacuum-jacketed pressure cylinders. They come equipped with safety relief valves and rupture discs to protect the cylinders from pressure buildup. These containers operate at pressures up to 350 psi and have capacities between 80 and 450 liters of liquid.



Side View

2.6 Dispensing Liquid Nitrogen and other Cryogenic Materials

DO NOT transfer liquid nitrogen from the high pressure outside bulk storage containers to low pressure cryogenic cylinders or Dewars, unless the low-pressure container is designed and designated to accept high-pressure material. Transferring high-pressure liquid nitrogen to incompatible containers is very dangerous.

Liquid Nitrogen and other Cryogenic Materials are to be dispensed only into smaller Dewars, which either have carrying handles or are on wheels, and have pressure relief valves or pressure venting lids. A wide-base Dewar that is stable on a wheeled cart qualifies as "on wheels".

To prevent splashing, place the filling hose at or below the mouth of the receiving vessel.

2.7 Transporting Cryogenic Materials by hand/cart

Large mobile Dewars or cylinders used for transporting cryogens within a building should be equipped with a braking mechanism. Do not use one's feet to "brake" wheels. Take care to avoid crushing hands or fingers between the Dewars and walls or door frames. Do not transport Liquid Nitrogen or other Cryogenic Materials in open containers.

Inside buildings the best transport from room to room is by using a Dewar that is equipped with carrying handles or is on wheels. The Dewar must have pressure relief valves or pressure venting lids.

- Note: A wide-base Dewar that is stable on a wheeled cart qualifies as "on wheels".

For short distances in hallways, it is acceptable to hand-carry a quart or smaller Dewar of liquid nitrogen or other Cryogenic Materials, which have no handles, as long as:

- The Dewar is your only load (no books, beverages, or other items);
- The Dewar has a venting lid (a cork or loose stopper is fine);
- You are carefully watching for people who will run into you;
- You are wearing appropriate PPE;
- The Dewar is carried with both hands and as far away from your face as comfortably possible.

2.7.1 Transport of Nitrogen and other Cryogenic Materials on an Elevator

Care must be exercised when transporting pressurized cryogenic containers on an elevator. Due to the confined nature of an elevator, a nitrogen gas or other cryogenic material leak from a pressurized container could produce an oxygen deficient atmosphere in a very small amount of time by displacing oxygen.

When a cryogenic liquid cylinder has been placed on an elevator, the elevator must travel between floors unoccupied. All elevator doors must be manned to prevent entry by person/s. Person/s must be stationed at all "in-between" floors to prevent riders from entering the elevator. The sender should remain outside the elevator and activate it to the desired floor. Another person should be available on the receiving floor to take the liquid container off the elevator at its destination.

DO NOT transport a pressurized container of Liquid Nitrogen or Cryogenic Material at any time in an elevator with any other person/s in the elevator car.

2.8 Storage of Liquid Nitrogen and Cryogenic Materials

- ➢ Store Cryogenic Materials in well-ventilated areas to prevent oxygen deficiency.
- ➢ Use only approved storage Dewars that have pressure relief valves.
- ➢ Never adjust, block, or plug a pressure relief valve.
- ➢ Avoid contact of moisture with storage containers to prevent ice plugs in relief devices.
- ➢ Periodically check container necks for ice plugs. If present, core out ice plugs.

- ➢ Keep all heat sources away from cryogenic liquids.
- ➢ Do not use cryogenic materials in walk-in cold rooms, because they may not have sufficient air exchange and could become hazardously oxygen deficient.

3.0 Training

Those employees who use gas cylinders or cryogenic materials as part of their job, should be trained in their proper use. Prior to use, a user must have completed training with an individual experienced in the use of compressed gases/cryogenics and who is aware of the hazards. The EHS Office also can assign an online Compressed Gas Safety and Cryogenic Safety course. In either case, an experienced individual must supervise newly trained users until they show competency.

Appendix I

Reference standards for compressed gases include:

- OSHA Standards for General Industry 29 CFR 1910

  1910.101 Compressed Gases (General Requirements)
  1910.102 Acetylene
  1910.103 Hydrogen
  1910.104 Oxygen
  1910.105 Nitrous Oxide
  1910.242(b) Compressed Air, cleaning
  1910.169 Compressed Air, receiver
  1910.253 Oxygen-fuel Gas Welding and Cutting

- DOT Hazardous Materials Regulations 49 CFR 171-179
- DOT Hazardous Materials Regulations 14 CFR 103
- Compressed Gas Association (CGA)

  Pamphlet No./ Description
  C-6-1968, Inspections
  C-8-1962, Inspections
  P-1-1965, In-plant Handling, Storage and Use
  S-1.1-1963 & 1965 addenda, Pressure Relief Devices
  8-1.2-1963, Pressure Relief Devices

- OSHA Construction Standards 29 CFR 1926
- ASME Boiler and Pressure Vessels Code Section VIII, III.
- AGA (American Gas Association)
- ANSI Z48.1 - 1954, 1965