GOVERNING REQUIREMENTS

The use, storage and handling of all compressed gases in cylinders shall be done so in accordance with the provisions of the Compressed Gas Associations as set forth in Pamphlet P-1 "Safe Handling of Compressed Gases."

I. General Guides for Use, Storage, & Handling Cylinders

a. All compressed gas cylinders must bear labels that clearly identify the contents.

b. Installed piping systems for flammable gases, toxic gases, and oxygen must be in accordance with OSHA, NFPA, and ANSI standards and approved by Gateway EHS Manager and/or Director of Facility Services.

c. Compressed gas cylinders must be supported at all times. They may be supporting by the following methods:

   i. Wall mounted or bench-mounted gas cylinder brackets.
   ii. Chains or belts that are anchored to a wall or bench.
   iii. Free standing dollies or carts designed for gas cylinders and equipped with safety chains or belts.

d. Individual cylinders or small groups of cylinders must be chained to a fixed object whether in use or in storage unless they are chained in a cylinder cart.

e. Store cylinders in designated areas where they will not be knocked over or damaged by passing or falling objects. Where cylinders are stored in the open, they should be protected from accumulations of ice and snow and from the direct rays of the sun. Full cylinders should be used in rotation as received from the supplier.

f. When an employee conducts a visual inspection and the cylinder is obviously damaged, it should be immediately returned to the supplier without the user attempting to use the compressed gas cylinder.

g. Cylinders should not be subjected to a temperature above 125˚ F, nor should a flame ever be permitted to come in contact with any part of a compressed gas cylinder.

h. ***Gas cylinders must have the valve protection cap in place except when in use***. A cylinder connected to a piece of equipment and properly supported is "in use". Remove the pressure regulators and replace the valve protection caps before moving cylinders, even if you have secured the cylinders to a dolly or a hand truck. (ex.: Do not transport acetylene and oxygen cylinders, used for cutting and brazing with the regulators attached to the cylinders, except in the cylinder cart.)

i. Do not drop cylinders or permit them to strike each other violently. Only cylinders approved for use in interstate commerce shall be used for the transportation of compressed gases.

j. Cylinders must not be filled except by, or with the consent of the owner and then only in accordance with the regulations of the Interstate Commerce Commission.

k. It is illegal to remove or change the numbers or marks stamped on cylinders.

l. Do not use a lifting magnet or a sling (rope of chain) when handling cylinders. A crane may be used when a safe cradle or platform carrier is provided to hold the cylinder(s) securely in place.

m. Do not use cylinders for rollers, supports, or for any purpose other than to carry gas.

n. Make sure that the threads on regulators or other unions are the same as those on cylinder valve outlets (CGA Valve Connections System). Never force connections that do not fit.

o. Regulators and pressure gauges provided for use with a particular gas must not be used on cylinders containing different gases.

p. ***Open cylinder valves slowly***. Never use wrenches or tools except for those that are provided or approved by the gas manufacturer.

q. ***Oxygen must be stored at least 20 feet from fuel gases such as acetylene, HPG, propane***, etc., or a fire-resistant partition must separate the classes of gases.

r. Post all hydrogen and/or acetylene storage and usage locations with permanent placards that read: "***Hydrogen/Acetylene – Flammable Gas – No Smoking – No Open Flames***".

s. The wrench used for opening the cylinder valve should always be kept on the valve stem when the cylinder is in use.

t. Caps are provided for valve protection. Such caps are to be kept on cylinders except when cylinder is in use.

u. Do not tamper with the safety devices in valves or cylinders. Never attempt to repair or alter cylinder valves.

v. Do not attempt to mix gases in cylinders. Close all cylinder valves when the cylinders are considered as being empty. This rule should be strictly enforced, including replacement of cylinder valve caps and marking or otherwise indicating that the cylinders are empty. ***Empty cylinders should be segregated from full cylinders and promptly returned to the supplier***.

w. Pressure regulators and gauges must be compatible with the cylinder valves (example: CGA Valve Connection System). The use of adapters, also known as "cheaters", is prohibited.

Note: All oxygen valves, gauges, regulators, pipes, and fittings must be thoroughly free of oil, grease, graphite, or any other oxidizable substance. Such pipes, gauges, fittings, etc., must at no time be allowed to come to an elevated temperature due to proximity to welding operations, burners, or other heat sources.

Although oxygen is quite safe under normal temperature and pressures, elevated temperature and/or pressure or contamination may result in the rapid and violent oxidation of normally non-reactive materials. For example, a regulator used on oil-pumped nitrogen could produce a serious explosion if subsequently used for oxygen due to the oil residue.

Storage Quantity and Volume

The maximum allowed usage and storage of flammable or toxic compressed gases within a laboratory work area are defined in Table I.

TABLE I

Maximum Expanded Volume Quantity (ft3) Limitations for Flammable, Toxic Compressed, or Liquefied Gas Cylinders in Laboratories (1)*

	Ventilated Enclosure Sprinklered Room	**Ventilated Enclosure Non-Sprinklered Room**	**No Ventilated Enclosure Sprinklered Room**	**No Ventilated Enclosure Non-Sprinklered Room**
Highly Toxic	40	20	No	No
Toxic	1620	810	No	No
Flammable	3000	1500	1500	750

Notes:

(1.) Consult Manufacturer or Gateway's Equipment Engineer for expanded volume data for various size cylinders.

(2.) Appendix C: Any material with a Health rating of 4.

(3.) Appendix C: Any material with a Health rating of 3.

(4.) Appendix C: Any material with a "y" in the flammability column (for materials classified as both flammable and toxic refer to the toxic limitations).

(5.) Use of small quantities (i.e. lecture bottles-2"X13")/dilute concentration gases in non-ventilated enclosures must be evaluated and approved by the EHS Manager.

*1994 Uniform Building Code and 1994 Uniform Fire Code

II. GASES WITH SPECIFIC HAZARD CLASSES

- **Flammable Gases** – Acetylene, Hydrogen, Methane, Propane and Iso-Butane

  i. Cylinders containing flammable gases are not be stored near highly flammable solvents, combustible waste material, and similar substances, or near unprotected electrical connections, gas flames, or other sources of ignition.

  ii. Reserve stocks of cylinders containing flammable gases are not to be stored with cylinders containing oxygen. Within buildings, assorted oxygen and fuel cylinders shall be separated by a minimum of 20 feet or there must be a fire-resistant partition (wall) between the oxygen and fuel gas cylinders.

  iii. Access doors to areas which use or store flammable gases shall be posted **"No Open Flames**".

  iv. Flames shall not be used for detecting leaks. A compatible leak detection solution shall be used for leak detection.

  v. Manifold systems shall be designed and constructed by competent personnel who are thoroughly familiar with the requirements for piping of flammable gases. Manifolds should comply with the standards of a recognized safety authority such as Underwriters Laboratories, Inc. Federal, state, local or insurance company specifications must be identified before starting design and construction. Consultation with the gas supplier before installation of manifolds is recommended.

- **Toxic and Poison Gases**

  i. Personnel handling and using poison gases shall have the following available for immediate use: Gas masks or self-contained breathing apparatus of a design approved by the U.S. Bureau of Mines for the particular service desired. Such equipment should be located convenient to the place of work, but shall be kept out of the area most likely to be contaminated.

  ii. Unless otherwise indicated, all gases must be stored in a continuously mechanically ventilated gas cabinet, fume hood, or other enclosure. Appropriate first aid and antidote information supplies must be provided and clearly marked at room entrances.

  iii. Small quantities (e.g. lecture cylinders) or dilute concentrations of these gases may be stored outside of a ventilated enclosure with the approval of Gateway EHS Manager or Director of Facility Services.

  iv. Audible alarms should be utilized in ventilated hoods that are dedicated to toxic gas usage or storage.

v. Standard Operating Procedures (SOP's) for processes or procedures which use corrosive, toxic or highly toxic gases shall be developed that include emergency response actions. All affected employees shall be trained on the contents of these procedures.

vi. The Interstate Commerce Commission requires the poison gas label on cylinders containing the following materials:

Bromo-acetone
Cyanogen
Cyanogen Chloride (containing less than 0.9% water)
Diphosgene
Ethldichloroarsine
Hydrocyanic Acid
Lewisite
Methyldichloroarsine
Mustard Gas
Nitric Oxide
Nitrogen Peroxide (Nitrogen Tetroxide)
Phenlcarbylamine Chloride
Phosgene

vii. Persons using these or other poison gases are advised to seek and secure pertinent information for proper handling from the manufacturer.

viii. Piping systems for flammable gases, toxic gases, and oxygen must be approved by Gateway EHS Manager or Director of Facility Services.

Note: Keep cylinders of all gases having a health hazard rating of three or four in hoods or other enclosures that vent directly outside. (Ex.: ammonia, carbonyl sulfide, hydrogen cyanide, hydrogen sulfide, methylamine, nitric oxide, etc.) Each hood or enclosure shall not have more than three cylinders of this type. Also, clearly marked first aid equipment, antidote information, and supplies at room entrances shall be provided. Material Safety Data Sheets must also be made available.

- **<u>Cryogenic Liquids and Gases</u>**

i. Use appropriate personal protective equipment (PPE) including insulated gloves and eye protection (goggles and face shield) during any transfer of cryogenic liquid.

ii. In the event of skin contact with cryogenic liquid, do not rub skin, place the affected part of the body in a warm water bath(not to exceed 40 C {105 F})

iii. Large vacuum insulated containers of pressurized liquid oxygen, nitrogen, argon, or helium must be transported, sorted, and used in an upright position. The extreme low temperature of the contents requires an upright position of the cylinders to permit venting of vapors

periodically to maintain safe internal pressures. The instructions of the supplier with regard to handling and use of these cylinders should be followed.

iv. Inspect containers for loss of insulating vacuum. If the outside jacket on a container is cold or has frost spots, some vacuum has been lost. Empty the contents into another cryogenic container and remove the damaged unit from service. Repairs should be made by the manufacturer or an authorized company.

v. Transfer operations involving open cryogenic containers such as dewars must be conducted slowly to minimize boiling and splashing of the cryogenic fluid.

vi. Ice or other foreign matter should not be allowed to accumulate beneath the vaporizer or the tank. Excessive ice buildup could result in the discharge of excessively cold gas or structural damage to the cryogenic container or surroundings.

- **Fuel, High Pressure and Oxidizing Gases**

The following information applies to the use and handling of fuel, high pressure and oxidizing gases:

i. Fuel gases often use a combination of flammable and oxidizing gases. Use of fuel gases must comply with ***29 CFR 1910.253***- Oxygen-Fuel Gas Welding and Cutting, ***29 CFR 1910.102***-Acetylene and ***29 CFR 1910.103***-Hydrogen. Additionally, adherence to the requirements of the Compressed Gas Association as defined in ***Pamphlet G-1: Acetylene***, ***Pamphlet SB-8***: Use of Oxy-fuel Gas Welding and Cutting Apparatus, and the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting and Allied Processes is required.

ii. High pressure gases can be rated up to 3000 pounds per square inch (psi). Typical uses include MIG welding gas mixtures, cryogenics, non-toxic gas distribution, medical gas distribution, and emergency oxygen services. In addition to any gas specific hazards, high pressure gases should carry the following hazard label:

CAUTION: HIGH PRESSURE GAS

iii. Oxidizing gases are non-flammable gases (i.e. oxygen chlorine, fluorine and nitrous oxide), but in the presence of an ignition source and fuel can support and vigorously accelerate combustion. Do not use oil in any apparatus where oxygen will be used. Gauges and regulators for oxygen shall bear the warning **"OXYGEN-USE NO OIL**".

III. GAS CYLINDER DISPOSAL

The following information applies to the disposal of compressed gas cylinders:

i. If possible, purchase compressed gas only from manufacturers that will agree to take back the empty cylinder.

ii. A cylinder is considered empty when the container pressure is at atmospheric pressure

iii. Refillable cylinders should be returned directly to the vendor.

iv. If a refillable cylinder is encountered that does not have a manufacturer label, contact vendor to see if they can identify the manufacturer through stamp marks on the cylinder.

v. Empty lecture-size cylinders may be given to EHS Manager (via hazardous waste removal form) for proper disposal.

vi. Maintain manufacturer labels and label the cylinder with an "Empty" or "MT" tag and place in the shipping/receiving area for pick up.

vii. EHS Manager should be contacted for disposal of partially full cylinders (if they are not to be picked up by vendor)

viii. Proper identification of the contents of all cylinders is required and is the responsibility of the cylinder owner.

ix. Disposal fees for ***unknown cylinders*** are a departmental expense.

a. Gas cylinders must have the valve protection cover cylinder cap in place while being transported (inter- and intra-building transport).

b. Motor vehicles used to haul compressed gas cylinders shall be equipped with racks or other means of securing the cylinders.

c. Cylinders (or dewars) containing liquefied hydrogen or toxic gases shall be transported in vehicles that are not enclosed.

IV. HANDLING COMPRESSED GAS CYLINDER LEAK & EMERGENCIES

Preplanning

Despite strict adherence to laboratory safety practices, accidents involving gases may occur in the laboratory. The amount of damage sustained by personnel and property from these accidents will be directly related to the quality of the laboratory's emergency plan and procedures. User of compressed gas cylinders must be familiar with necessary safety

precautions. Standard Operating Procedures (SOPs) for experiments using compressed gases shall include a discussion of possible accident scenarios, appropriate employee responses and should take into account the following factors:

i. The nature of the operation (i.e., experimental design, equipment used and type of injury that might be inflicted).

ii. The potential location of a release or spill (i.e. outdoors versus indoors, in a laboratory, corridor or storage area, on a table, in a hood or on the floor)

iii. The quantities of material that might be released and the type of containment (i.e. compressed gas tank size, manifold systems, etc.)

iv. The chemical and physical properties of the compressed gas (i.e. its physical state, vapor pressure and air or water reactivity).

v. The hazardous properties of the compressed gas (i.e. its toxicity, corrosively and flammability).

vi. The availability and locations of emergency supplies and equipment.

vii. A contingency plan which identifies building evacuation routes, emergency telephone numbers, chemical containment procedures, fire extinguisher usage, etc., should be posted in the lab.

Minor Leaks

Occasionally a gas cylinder or one of its component parts may develop a leak. Most of these leaks occur at the top of the cylinder in areas such as the valve threads, pressure safety device, valve stem and valve outlet. The following information applies to the remediation of minor leaks:

i. If possible, verify suspected leaks using flammable gas detector or soapy water solution (a flame should not be used for detection**). If the leak cannot be stopped by tightening a valve gland or packing nut, emergency action procedures should be initiated and the EHS Manager and/or Director of Facility Services should be notified.**

ii**.** For flammable, inert or oxidizing gases move the cylinder to an isolated, well-ventilated area (i.e. within a fume hood) away from combustible materials. Post signs that describe the hazard.

iii. For corrosive and toxic gases, move the cylinder to an isolated, well-ventilated area (i.e. within a fume hood) and use suitable means to direct the gas into an appropriate chemical neutralizer. Post signs that describe the hazards.

iv. If it is necessary to move a leaking cylinder through populated portions of the building, place a plastic bag, rubber shroud or similar device over the top and tape it(duct tape preferred) to the cylinder to confine the leaking gas.

Major Leaks

In the event of a large gas release or if an accident takes place in which readily available personal protective equipment (PPE) is inadequate to ensure worker safety, activate the **following Emergency Procedures**:

i. **Immediately call 911** and report the incident.
ii**. Activate** area fire alarms
iii. Evacuate the area, securing entrances and providing assistance to others on the way out. Call EHS Manager once outside (419-9397)
iv. Provide Emergency response officials with details of the problem upon their arrival. The Greensboro Haz-Mat team will respond to all chemical Emergencies at JSNN.

Accidents Involving Personnel Injury

i. For medical emergencies, call 911.
ii. Assist person involved and administer immediate first aid which may include:
   a. Washing under a safety shower (in case of burning clothing or chemical exposures).
   b. Removing contaminated clothing.
   c. Irrigating the eyes at eyewash.
   d. Administering artificial respiration (CPR).
ii. Notify personnel in adjacent areas of any potential hazards (i.e. activate area fire alarms)
iv. Move injured personnel only if necessary to prevent their exposure to further harm.

Fire and Fire-Related Emergencies

For all fires, immediately call 911. Small isolated fires within the laboratory may be extinguished using the appropriate portable fire extinguisher if lab personnel are confident that they can safely extinguish the fire. Additional information on fire extinguisher use is contained in Gateway's Fire and Emergency Guidelines. Copies are available from the EHS Manager.

For large or rapidly spreading fires, the following procedures should be followed:

i. Call 911 to report the fire.
ii. Activate the area fire alarm.
iii. Evacuate the building, shutting doors and providing assistance to others on the way out. Contact the EHS Manager (419-9397) once outside.
iv. Provide the fire or police officials with the details of the problem upon their arrival.

Effective Date: 10-30-12

APPENDIX A

Definitions

Absolute Pressure: Based on a zero pressure reference point, the perfect vacuum. Measured from this point, standard atmospheric pressure at sea level is 14.7 pounds per square inch (psi) or 101.325 kilo Pascals (kPa). This is usually expressed as psia where the 'a' indicates an absolute measurement or kPa.

Asphyxiant Gas: Any non-toxic gas which displaces atmospheric oxygen below limits required to support life. These gases are usually colorless, odorless and tasteless and include nitrogen, argon and helium.

Compressed Gas: A compressed gas is any gas which when enclosed in a container gives:

- an absolute pressure reading greater than 276 kPa (40 psi) at 21°C (70°F) or
- an absolute pressure greater than 717 kPa (104 psi) at 54°C (129.2°F) or
- any flammable liquid having a vapor pressure greater than 276 kPa (40 psi) at 38°C (100.4°F).

Compressed Gas Cylinder: A compressed gas cylinder is any metal cylinder of the type approved by the U.S. Department of Transportation (DOT) for storage and transportation of gases under pressure, including liquefied gases. Metal cylinders are the only approved DOT packaging for compressed gases.

Corrosive Gas: A gas that in contact with living tissue causes destruction of the tissue by chemical action.

Cryogenic Liquid: A liquid with a normal boiling point below -150°C (-238°F).

Cryogenic Liquid Cylinder: Pressurized container designed and fabricated to hold cryogenic fluids. There are three common types of liquid cylinders: gas dispensing; liquid dispensing; or gas and liquid dispensing.

Cylinder Valve: A mechanical device attached to a compressed gas cylinder that permits flow into or out of the cylinder when the device is in the open position and prevents flow when in the closed position.

Dewar: Is an open-mouthed, non-pressurized, vacuum-jacketed container used to hold cryogenic fluids.

Flammable Gas: A substance that meets the definition of a compressed gas which:

- is flammable in a mixture of 13% or less (by volume) with air, or
- has a flammable range with air wider than 12%, at atmospheric temperature and pressure, regardless of the lower limit.

Gauge Pressure: The pressure above or below atmospheric pressure. Therefore absolute pressure minus local atmospheric pressure equals gauge pressure and is usually abbreviated as psig or kPa.

Handling: Moving, connecting or disconnecting a compressed or liquefied gas container under normal conditions of use.

Highly Toxic Gas: A compressed gas that has a median lethal concentration (LC_{50}) in air of ≤ 200 ppm. A NFPA Health Hazard rating of 4 is given to gases having an LC_{50} in air ≤ 1000 ppm. An example of a highly toxic gas is fluorine with a LC_{50} of 185 ppm. See Appendices C and D.

High Pressure Gas: A gas in a container that has a pressure of 3448 kPa (500 psig) or higher at 21.1°C (70°F).

Inert Gas: A gas which is chemically inactive.

Liquefied Gas: A fluid within a pressurized container, other than in solution, which exists both as a liquid and gas at 20°C (68°F). Examples include propane, butane, ammonia, carbon dioxide, and sulfur dioxide.

Manifold: A gas distribution system which transfers product through multiple outlets/inlets to or from compressed gas containers.

Nonflammable Gas: A gas which, within the packaging, exerts an absolute pressure of 280 kPa (40 psi) or greater at 20°C (68°F) but is not a flammable gas as defined previously.

Oxidizing Gas: A gas that can support and accelerate combustion of other materials.

Poison Gas: Defined by DOT in 49 CFR 173.133. See toxic gas.

Pressure Regulator: A mechanical device used to safely control the discharge pressure of a compressed gas from a container.

Pressure Relief Device: A pressure and/or temperature activated device used to prevent the pressure from rising above a predetermined maximum and thereby prevent rupture of a pressurized container.

Pyrophoric Gas: A gas that will spontaneously ignite in air at or below 54.4°C (130°F). Examples include silane and phosphine.

SCF: One standard cubic foot of gas at 21°C (70°F) and 101.325 kPa (14.696 psia).

Storage: Holding of gas, in its packaging, either on a temporary basis or for an extended period in such a manner as to not constitute usage of the gas.

Toxic Gas: A gas having a Health Hazard of 3 or 4 as defined in NFPA 704, *Standard System for the Identification of the Fire Hazards of Materials.* See Appendices B and C.