Compressed Gas Safety

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1.0 Purpose and Applicability

This safety guidance for handling compressed gases provides basic information, including compressed gases classification and their hazardous properties, storage, handling and use, transportation and relocation, and disposal of cylinders.

This guidance is applicable to all research and teaching laboratories and non-laboratory areas (facility management, machine shops, studio arts, etc.), where compressed gas cylinders and refrigerated liquefied gases are stored and used. This document meets the Hazard Communication Standard 2012 and GHS classification and labeling criteria.

Other OSHA regulations pertaining to compressed gas cylinders include:
29 CFR 1910.101 and 1910.252 (general requirements)
29 CFR 1910.102 (acetylene)
29 CFR 1910.103 (hydrogen)
29 CFR 1910.104 (oxygen)
29 CFR 1910.105 (nitrous oxide)

2.0 Classification of Gases

Major Groups of Compressed Gases
"Compressed Gas" is a generic term used for describing 1) compressed gases, 2) liquefied compressed gases, 3) refrigerated liquefied gases (cryogenic gases), and 4) dissolved gases.

Compressed Gases
Compressed gases are non-liquefied gases. Compressed gases do not become liquid at normal temperatures, even at very high pressures. Examples include helium, nitrogen, oxygen, and argon. A compressed gas is either:

- A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 pounds per square inch (psi) at 70° F (21° C);
- A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 F regardless of the pressure at 70° F(21° C); or
- A liquid having a vapor pressure exceeding 40 psi at 100° F (38° C); as determined by ASTM D-323-72.

Compressed gases are stored in heavy-walled metal cylinders that are manufactured to withstand high pressure. Compressed gas cylinders are available in different sizes (1 to 6 feet length). Compressed gases are filled under high pressure exceeding 2000 psi.

Gases are classified to meet US department of Transportation (DOT) and IATA regulations. The DOT has adopted GHS guidelines for classification, labeling/signage and safety data sheets (SDSs), and compressed gases are classified as Class 2, Class 5, and/or Class 6 gases). The OSHA and DOT pictograms that are used for the classification of compressed gases are given below.

OSHA and DOT Pictograms for Compressed Gases

The intrinsic properties of a gaseous chemical inside the cylinder may present hazardous situation when released in to the atmosphere or work areas.

Hazardous properties of compressed gases are classified as below:

(1) Corrosive reactions to equipment and human tissue;
(2) Generation of flammable gas and acutely toxic intermediates (poison);
(3) Oxidizing reactions; and
(4) Generation of an asphyxiating environment;

The GHS classification of commonly used general and specialty gases, along with the intrinsic hazardous properties and respective pictograms, are summarized in Appendix A.

Liquefied Gases

Liquefied gases are gases that become liquid at normal temperatures when they are pressurized inside a gas cylinder. The cylinder is initially filled as a liquid. The liquid then evaporates to a gas and saturate the head space above the liquid and maintains liquid-vapor equilibrium. As gas is released from the cylinder, enough liquid evaporates to the head space, thus keeping the pressure in the cylinder constant. Examples of liquefied gases include ammonia, carbon dioxide, chlorine, methane, natural gas, and propane.

Refrigerated Liquefied Gases (Also Known as Cryogenic Liquids)

Refrigerated liquefied gases also known as cryogenic liquids are kept in their liquid state at very low temperatures. Refrigerated liquefied gases are extremely cold with boiling points below - 150° C. Refrigerated liquefied gases are heavier than air under cold temperature conditions and can accumulate near the floor. The vapors and gases released from refrigerated liquefied gases can be extremely cold and can result in frost bites and blisters. Small amounts of refrigerated liquefied gases liquid can expand into very large volumes of gas.

Examples of refrigerated liquefied gases include liquid helium, liquid nitrogen, and liquid argon. Carbon dioxide and nitrous oxide, which have slightly higher boiling points, are also included in this category.

Dissolved Gases

Acetylene is the only commonly used dissolved gas. It is chemically very unstable. Even at atmospheric pressure, acetylene can explode. Yet, acetylene is routinely stored and used safely in cylinders at high pressures, up to 250 psi at 21° C. If an acetylene cylinder has been accidentally left on its side, set the cylinder in upright position for at least an hour before use. Otherwise, dissolved gases have the potential to emit a burst of liquid solvent instead of gas when the valve is opened.

3.0 Hazardous Properties of Compressed Gases

Compressed gases can have one or more hazardous properties. Researchers should consult the appropriate SDS for detailed information on the active chemical ingredients and composition in the gas cylinder, and associated physical and health hazards. Specific handling and storage information is outlined in section 7 of the SDS. Also, gas specific SDSs describe appropriate exposure controls and personal protective measures in section 8 of SDS.

High Pressure Hazards

All compressed gases are hazardous because of the high pressures inside the cylinders. Even at a relatively low pressure, gas can flow rapidly from an open or leaking cylinder. Damaged cylinders can become rockets/missiles or pinwheels resulting in severe injury and property damage. An unsecured or uncapped cylinder can become a cause of a major accident in the lab. If an unsecured cylinder is knocked over and the cylinder valve breaks, the gas can escape at a velocity of the missile. A poorly controlled release of a compressed gas in chemical reactors can also cause vessels to burst, create leaks in equipment or piping, or produce run-away reactions.

The pressure of the gas or gas mixture in the cylinder is indicated on the pressure gauge both in psi and kPa. Researchers should ensure not to empty the cylinder completely, but maintain at least 25 psi residual pressure in the tank.

Hazards of Refrigerated Liquefied Gases - Cryogenic Temperature

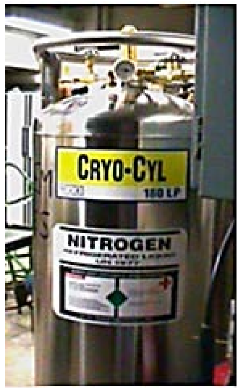
The DOT requires the Division 2.2 label for nonflammable and nonpoisonous refrigerated liquefied gases such as liquid helium, liquid nitrogen and liquid argon.

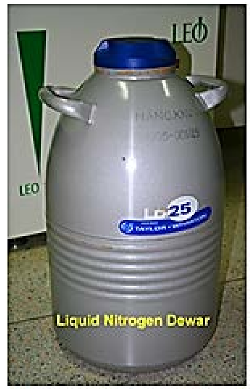
Safety

- **Individuals should be properly trained in the safe handling of refrigerated liquefied gases such as liquid helium, liquid nitrogen and liquid argon.**
- **It is strongly recommended that the first time users in the lab should be adequately trained in the transfer of liquefied gases from one container to another under the direct supervision and instruction of a senior staff experienced in the handling of liquefied gases.**
- **Thermal gloves should be used to protect against cryogenic liquid temperature and the gloves should be loose enough to remove quickly during an emergency to prevent tissue damage.**

Even brief contact with a cryogenic liquid is capable of causing tissue damage and blisters similar to thermal burns. Prolonged contact may result in blood clots and serious personal injury. Also, surfaces cooled by cryogenic liquids can cause severe damage to the skin. Solvents that are cooled using dry ice-isopropanol or dry ice-acetone mixtures can easily reach -70° C or lower) and proper thermal insulated gloves must be worn to protect against cold frost and skin blisters.

It is important to work in a well-ventilated area when transferring liquid nitrogen to cool the vacuum trap because oxygen from the ambient air can condense in the cryogenic trap and lead to a potentially explosive condition. Similarly, do not use liquid nitrogen or liquid air to cool a flammable liquid or solvent mixture in the presence of air because oxygen from the air can condense in the flask and lead to a potentially explosive condition.





Small amounts of refrigerated liquefied gases can evaporate into large volumes of gas. For example, one liter of liquid nitrogen can vaporize and expand to 695 liters of nitrogen gas at ambient temperature and pressure. Even if the refrigerated liquefied gas is not toxic, it will displace the air in the storage area. Oxygen deficiency is a serious health hazard in enclosed or confined spaces. As a result of oxygen deficiency, asphyxiation can occur.

Liquid Dewars, cylinders and other vessels used for the storage and handling of refrigerated liquefied gases should not be filled to more than 80% capacity, to prevent the possibility of thermal expansion and bursting of the vessel. Use appropriate impact-resistant containers that are designed to withstand extremely low temperatures.

Flammable Hazards

The DOT requires a red flammable gas pictogram and a Division 2.1 gas label. Flammable gases include acetylene (dissolved gas), butane, ethylene, hydrogen, methylamine, and vinyl chloride.

Each flammable gas has a specific flammable range. For a gas to be flammable its concentration in air should be between its lower flammable limit (LFL) and its upper flammable limit (UFL). For example, hydrogen's LFL in air at atmospheric pressure and temperature is 4% and its UFL is 75%. This means that hydrogen can be ignited when its concentration in air is between 4% and 75%. However, the flammable range of any gas is widened in the presence of oxidizing gases such as oxygen or chlorine and by higher temperatures and pressures.

For a flammable gas within its flammable range in air or an oxidizing agent to ignite, an ignition source usually needs to be present. Ignition sources can include such things as open flames, sparks, and hot surfaces. However, some gases can also auto-ignite without any obvious ignition sources and others can ignite spontaneously in air – always review the SDS for proper storage and handling!

Flashback can occur with flammable compressed gases that are heavier than air. If a cylinder leaks in a poorly ventilated area, such gases can settle and collect in sewers, pits, trenches, or low areas in workspaces. The gas trail can spread very far from the cylinder and if it contacts an ignition source, the fire produced can flash back to the cylinder.

Oxidizing Hazards
Oxidizing gases are labeled by the DOT as Division 2.2 and Division 5.1 (Oxidizer). Oxidizing gases include any gases containing oxygen at higher than atmospheric concentrations (23-25%), nitrogen oxides, and halogen gases such as chlorine and fluorine.

Warning

- **Fires in atmospheres enriched with oxidizing gases are very hard to extinguish and can spread rapidly.**
- **Never use oxygen in place of compressed air or nitrogen to purge gas lines**

The flammable gases can react rapidly and violently with combustible materials resulting in fire or explosion. Such combustible materials include oils, greases, plastics, fabrics; finely divided metals, hydrazine, hydrogen, hydrides, sulfur compounds, silicon, and ammonia or ammonium compounds.

Researchers should receive special cleaning instructions from the specific gas supplier (such as Praxair) for any equipment that uses oxidizing gases. Gaskets should be made of noncombustible materials. Any parts of the cylinder and fittings should not be handled with bare hands contaminated with grease or oil. Similarly, rags and gloves that are contaminated with grease or oil should be kept away from oxidizing gas operations. Use only lubricants and connection or joint sealants recommended by the gas cylinder manufacturer or supplier.

Reactive Hazards
Some vigorously reactive gases include acetylene, 1,3-butadiene, vinyl chloride, and vinyl methyl ether.

Some high purity compressed gases are chemically unstable. Vinyl gases, if exposed to elevated temperature, pressure, or mechanical shock, can undergo polymerization or decomposition. Uncontrolled polymeric reactions can become violent, resulting in fire or explosion. Some reactive gases are mixed with polymerization inhibitors to prevent the hazardous reactions.

Corrosive Hazards
Corrosive gases are labeled by the DOT as Division 2.3 and Division 8 (Corrosive). Corrosive gases in this group include ammonia, hydrogen chloride, chlorine, and methylamine. Corrosive compressed gases can burn and destroy body tissues on contact. Corrosive gases can also attack and corrode metals.

Toxic (Poison) Hazards
Toxic gases have the potential to cause adverse health effects depending on the specific gas, its concentration, the length of exposure, and the route of exposure (inhalation, eye or skin contact).

Safety

- **The fume hood sash should be lowered below the breathing zone of researchers. Researchers should wash their hands with soap and water immediately after handling toxic compressed gases.**
- **The DOT requires THE WHITE POISON LABEL or the label identification shows Division 2.3 because toxic gases under this division are known to be toxic to humans.**

DOT Classification of Toxicity of Gases

The toxic gases are labeled by the DOT as Division 6.1A, 6.1B, 6.1C. Gases having inhalation LC50 (lethal concentration, 50%) up to 2500 ppmv (parts per million by volume) are classified as acutely toxic gases but with differing severity such as A, B, or C as shown below.

DOT Division	Description
Class 6.1**A** LC 50 is < 100 ppmv	6 = Toxic. 1 = Acutely toxic. A = An inhalation LC50 less than or equal to 100 ppmv of the substance as gas in air by inhalation route. An oral LD50 less than or equal to 5 milligrams of the substance per kilogram of bodyweight.
Class 6.1**B** LC 50 is 100 - 500ppmv	6 = Toxic. 1 = Acutely toxic. B = An inhalation LC50 is in the range 100 to 500 ppmv as a gas in air by inhalation route. An oral LD50 greater than 5 milligrams, but less than or equal to 50 milligrams of the substance per kilogram of bodyweight.
Class 6.1**C** LC 50 is 100 - 2500ppmv	6 = Toxic. 1 = Acutely toxic. C = An inhalation LC50 greater than 500 PPM, but less than or equal to 2500 PPM of the substance as gas in air by inhalation route. An oral LD50 greater than 50 milligrams, but less than or equal to 300 milligrams, of the substance per kilogram of bodyweight.

Toxic gases in research laboratories include arsine, boron trifluoride, chlorine, carbon monoxide, cyanogen, fluorine, hydrogen cyanide, hydrogen fluoride, hydrogen sulfide, phosphine, and phosgene. DOT Divisions for specific hazardous gases are summarized below.

DOT Division	Example Common Gases	Hazardous Property	Signal Word
2.1.1A	Acetylene, butane, carbon monoxide, hydrogen, methane, propane, ethylene oxide	Highly flammable gas. (Keep valve closed when not in use.)	Danger
2.1.1B	Anhydrous ammonia gas, methyl bromide	Flammable gas. (Keep valve closed when not in use.)	Danger
2.1.2A	Flammable aerosol –pressurized canisters	Flammable. (Keep away from heat sources.)	Warning

2.2	Nonflammable gas (no classification), compressed air, argon, nitrogen, helium, carbon dioxide, balloon gas, refrigerant gas	Non-toxic compressed gas.	Warning
5.1.2A	Oxygen gas, oxygen liquid, chlorine	Oxidizing gas. (Keep away from open flames; can cause intense fire.)	Danger
2.3 or 6.1A, B, C	Anhydrous ammonia, carbon monoxide, chlorine, nitrous oxide, phosgene, sulfur dioxide, insecticidal gases	Toxic, fatal if inhaled (Avoid inhalation)	Danger

NFPA Classification of Toxicity of Gases

Gases are described by NFPA as **ACUTELY TOXIC** if:

(1) NFPA health rating is 4 and inhalation LC50 is zero to <1000 ppmv
(e.g., arsine, hydrogen selenide, and stibine)

(2) Or NFPA health rating is 3 and inhalation LC50 is ≥ 1000 ppmv, but < 3000 ppmv
(e.g., boron trifluoride, and hydrogen fluoride)

Gases are described by NFPA as **TOXIC** if
NFPA health rating is 2 and inhalation LC50 is greater than 3000 ppmv and up to 5000 ppmv
For accurate NFPA hazard rating of pure gases and mixtures, researchers are highly encouraged to review the product specific SDSs supplied by the gas supplier.

The GHS Classification of Toxicity Health Hazard for Gases

The GHS classifies the compressed gases by categorizing them as shown below. Detailed GHS classification of general and specialized gases used in research laboratories are summarized in Appendix A. This is not an exhaustive list.

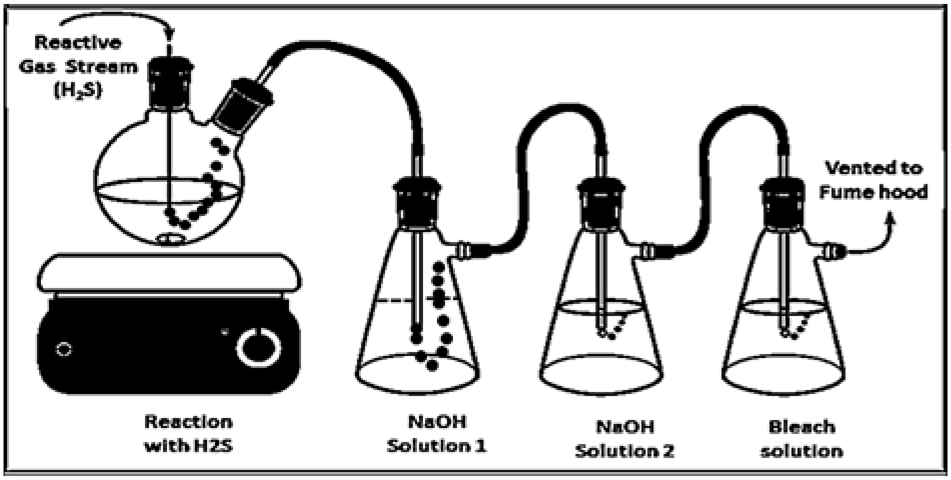
GHS Classification			
Gases concentration in ppmv		Vapors ppmv	
Category	LC 50 concentration ppm	Category	LC 50 concentration ppmv
Category 1	0 to 100 ppmv	Category 1	0 to 0.5 ppmv
Category 2	100 to 500 ppmv	Category 2	0.5 to 2 ppmv
Category 3	500 to 2500 ppmv	Category 3	2 to 10 ppmv
Category 4	2500 to 20000 ppmv	Category 4	10 to 20 ppmv

Special Procedures for Hazardous Gases

It is highly recommended that appropriate engineering controls, neutralizing traps or charcoal based gas adsorbers be installed for toxic gases in consultation with the toxic gas suppler prior to purchase and use in research labs.

All toxic gases including acutely toxic gases should be used in a functioning fume hood or other vented engineering controls, or vented gas cabinet with appropriate scrubber or gas absorber, and exhausted outside through the fume hood duct work. Larger sized reactive gas cylinders such as sulfur dioxide, diborane, silicon tetrafluoride, should be stored in a vented gas cabinet with appropriate gas adsorbing scrubbers as recommended by the gas manufacturers and exhausted outside through the fume hood duct work. Certain charcoal based gas adsorbers for volatile gases can be purchased through Thermo Fisher, Sigma-Aldrich or Matheson TRIGAS companies

Laboratory experiments with low flow reactive gases can be safely controlled and neutralized using a simple scrubber train and exhausted to fume hood duct work as shown below.



Simple Asphyxiant (Inert Gases) Hazards
Typical examples of inert gases include argon, helium, neon and nitrogen and are labeled by the DOT as Division 2.2.

Inert gases are nonflammable, not oxidizing and nontoxic. However, inert gases can cause severe health injury or death at high concentrations by displacing oxygen in the air. If the oxygen level falls too low, individuals in the area or entering the area can lose consciousness or die from asphyxiation. Always use inert gases in well-ventilated areas.

4.0 Labels and Signage

Safety

- **Never use a cylinder whose contents cannot be positively identified. All cylinders should bear an identification tag stating the name of the gas or mixture and a tag stating one of three conditions: full, in-service, or empty.**
- **Improper handling of hazardous substances can cause injury, ill health to a person and cause damage to property or the environment.**

Labels
All compressed gas cylinders are clearly labeled with the correct name of their chemical contents by the gas manufacturer or supplier according to DOT and OSHA regulations. Manufacturer labels on gas cylinders include gaseous chemical name, composition, and hazardous properties as shown below.

Physical hazard, health hazard and DOT class of significant laboratory gases are listed in Appendices 1 and 2.

- Never rely on the color of the cylinder for gaseous chemical identification. Color-coding is not reliable because colors can vary with the supplier, they can appear different under artificial lights, and some people are color blind.
- Never rely on the color of the cylinder cap for gaseous chemical identification
- Never rely on the label affixed on the cap, if any. Caps can be easily interchanged.
- Never use a cylinder whose contents cannot be positively identified.
- Do not remove or deface any marks or tags attached to the cylinder by the supplier.
- If the labeling or the attached tag on a cylinder becomes unreadable or is missing, the cylinder should be marked “contents unknown” and returned to the supplier.

One of three cylinder conditions, namely (**FULL, IN-SERVICE, OR EMPTY)** should help the researchers to identify the cylinder status. The three part tags can be purchased from Thermo Fisher, VWR, Grainger (previously Lab Safety Supply) or other safety supply vendors. An example of commercially available three-part tag and the in-house usage is depicted in the example picture below.

All gas lines leading from a compressed gas supply should be clearly labeled with the identity of the gas, the laboratory or area served, and pertinent emergency telephone numbers.

Signage

It is recommended that an appropriate “Danger” or “Warning” sign be posted where acutely toxic, corrosive, oxidizing, or flammable gases are stored, handled (GHS Health hazard 1 to 3 or NFPA 4 and 3) or used. Gas specific signs can be purchased from Thermo Fisher, VWR, Grainger (previously Lab Safety Supply) or other safety supply vendors.

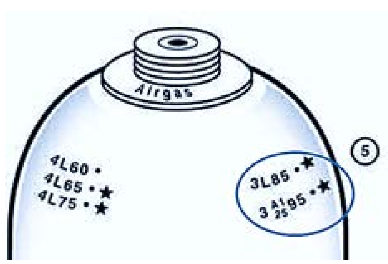
My safety Sign.com [http://www.mysafetysign.com/]

5.0 Purchasing and Receiving

Avoid purchasing larger sized cylinders than are necessary. Several large cylinders stored in a lab area can potentially increase the risk in the event of an accidental release. Also, storage of several cylinders in a single lab restricts ambient use of space for other important research applications.

Visually inspect every incoming cylinder to the lab and ensure that they are not damaged during transport. Do not accept delivery of defective cylinders. Check for any leaks, which may be indicated by odors, visible fumes, corrosion, or hissing sounds. Ensure the valve cover or shipping cap is properly in place.

Typically, the physical integrity of the cylinders is tested every 10 years by the manufacturer. There should be a **LAST TEST DATE** on the top of the cylinder as shown below. If outdated cylinders are identified at the time of receiving, immediately notify the cylinder supplier.



Prior to use in the lab, researchers should check the identification labels on the cylinder for the name and description, and the compositions are the same as on the purchase order and appropriate for the intended use.

6.0 Transport, Security, and Storage

Every compressed gas cylinder should be treated as a potential high energy projectile or missile and, therefore, gas cylinder should be secured at all times to prevent tipping.

Safety

- **Never transport a cylinder without the cap in place.**
- **Use a suitable handcart for moving cylinders. Secure the cylinder by chaining to the cart.**

- **Do not lift cylinders by the cap.**
- **Never carry a cylinder by its valve and do not roll or drag cylinders**

The cap is installed for the protection of the cylinder valve and, therefore, gas cylinders should be capped when not in use. Prior to transporting or relocating a cylinder, remove the regulator and attach the cylinder cap. The cylinder cap should be screwed all the way down on the cylinder's neck ring and should fit securely.

Use a suitable handcart for moving cylinders and secure the cylinder with a cart chain. It is strongly recommended that researchers should move only one gas cylinder at a time to a designated location in the lab.

Cylinders may be attached to a bench top, individually to the wall, placed in a holding cage, or have a non-tip base attached. Chains or sturdy straps are used to secure them at a point approximately 2/3 the height of the cylinder at all times. If installation of wall chains or bench straps is needed, contact the University Work Control Center.

EMPTY cylinders should be properly tagged as shown in section 4 "Labels and Signage" and stored separately from **FULL** cylinders. Never store cylinders in a hallway, near the doors, or other means of egress.




Special Storage Conditions

NFPA Precautionary Guidance

- **A typical laboratory may have no more than three standard cylinders of flammable gases and/or oxygen; two of liquefied flammable gases; and three 4"x15" cylinders (or volume equivalent) of gases with high health hazard ratings.**
- **Gases with NFPA Health Hazard Ratings of 3 or 4 (or a rating of 2 with no physiological warning properties) SHOULD be kept in a hood or other continuous mechanical ventilation.**
- **No more than three cylinders with ratings of 3 or 4 can be kept in one enclosure.**

Useful Life Span

Recommended retention periods for compressed gases are 36 months for liquefied flammable gases, flammable gases, and oxygen; and 6 months for corrosive or unstable gases or those with an NFPA Health Hazard Rating of 3 or 4.

Ambient Storage Temperature

Cylinders should be protected from extreme weather, direct sunlight, and other heat sources. The storage temperatures should not exceed 100° F. Do not subject cylinders to temperatures below –20° F, unless they are designed for such temperatures.

Flammable gases

Maintain at least 20 feet from flammable liquids, sources of heat, and cylinders of oxygen or other oxidizers such as nitrous oxide. Bond and ground the cylinder, lines, and equipment.

Oxygen

Never use grease or solvents on valves and fittings. Regulators and tubing/piping should be specially cleaned to remove oil, etc., prior to using piping of gases.

Inert gases

Inert gases should be stored in a ventilated area because leaks in closed spaces can displace oxygen.

Toxic gases with inhalation LC50 less than 3000 ppmv

Store and use in vented enclosure or fume hood. Gas specific vented cabinets should be purchased and installed as recommended by the gas manufacturer or supplier

7.0 Personal Protective Equipment

Portable safety shield in work locations

If stored and used within a chemical fume hood, the use of a portable process safety shield in front of corrosive and highly reactive gas cylinders and lecture bottles can help protect researchers against a potential explosion, splashing, or a highly exothermic reaction.

Eye Protection

OSHA requires safety glasses be worn underneath a full-face shield.

Wear safety glasses with side shields or face shield when transporting compressed gas cylinders. A full-face shield should always be used if a potential splashing hazard is present (e.g. bubbling or head space purging of reaction flasks with inert gases, etc.). Wear safety glasses and a face shield when working with regulators, gas tubes and Schlenk lines. Wear face shield and chemical resistant safety goggles when dispensing refrigerated liquefied gases from a cylinder or liquid Dewar.

Lab coat/Coverall/Shoes
A lab coat, closed-toed shoes and long pants (**NO SHORTS**) should be worn when handling compressed gas cylinders. Sturdy shoes are a minimum when moving or transporting cylinders.

Hand Protection
Wear chemically resistant gloves suitable for the gas being handled. Wear appropriate insulated thermal gloves to protect against extreme cold when handling cryogenic containers. Use long loose thermal gloves while handling or pouring cryogenic liquids.

8.0 Set Up and Usage

Safety

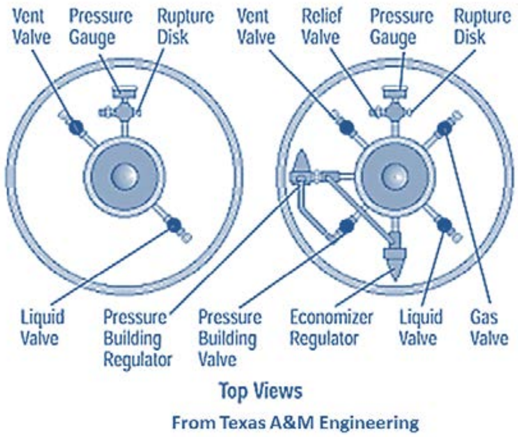
- **Always have the regulator valves pointed away from you when opening or closing valves.**
- **Never install cylinder adapters on a regulator.**
- **Do not attempt to repair cylinders or cylinder valves or force open cylinder valves. Contact the compressed gas supplier for advice.**

Cylinder Valves, Regulators, or Other Fittings
Set up the gas cylinder so that its valve is easily accessible at all times. For cylinders equipped with a stem valve, the valve spindle key should remain on the stem when the cylinder is in service.

Prior to use, the threads on cylinder valves, regulators, and other fittings should be inspected to ensure compatibility. To prevent the mixing of incompatible gases, the Compressed Gas Association (CGA) has devised standard cylinder-valve outlet connections. Since outlet threads used vary in diameter and placement, the use of CGA-standard combinations of valves and fittings is recommended. Correct CGA regulator numbers for the commonly used laboratory gases are listed below.

Common Laboratory Gas	CGA Regulator Number
Nitrogen	580
Helium	580
Argon	580
Carbon dioxide (fitting requires flat washer)	320
Air (non-medical grade, zero air)	590
Air (medical grade)	346
Hydrogen	350
Methane	350
Acetylene (except small cylinders)	510
Propane	510
Oxygen	540

Refrigerated liquefied gas tanks/cylinders usually have a number of valves on the top of the cylinder. All valves should be clearly marked as to their function. These cylinders can vent the gas or vapor when a preset internal cylinder/tank pressure is reached, therefore, it is very important that they are stored or placed in service where there is adequate ventilation.



Safety

- Only gas cylinder specific special wrenches or keys provided by the cylinder supplier should be used to open or close cylinder valves. Or contact Steve Stange at 384-4045 for help.
- Do not use a wrench to open or close a hand wheel-type cylinder valve. Never use pliers!
- Never use a Monkey wrench to loosen the gas cylinder cap.

Testing for Leaks

Leak test all connections to a cylinder because any gas, regardless of its health hazard, may cause asphyxiation by displacing oxygen. Piping systems should also be inspected for leaks on a regular basis. Leak detection procedures should be implemented prior to using any compressed gas system.

Opening and Closing Cylinders

(1) Open the cylinders slowly, with the valve pointing away from you and others, and open it all the way.

(2) Do not use excess pressure if you cannot open it by hand. It is strongly advised to contact the gas cylinder supplier for a replacement gas cylinder.

(3) Close the cylinder valves when not in use, and then bleed pressure from the regulator.

(4) Avoid leaving the valve open when the cylinder is not in use, even when empty.

(5) Leave at least 25 psi in spent cylinders to prevent suck-back contamination.

(6) Air and moisture may diffuse through an open valve causing contamination and corrosion within the cylinder.

(7) Store the cylinders with caps in place.

Things to Avoid

(1) Do not attempt to use a cylinder without a regulator or some other pressure-reducing device in place.

(2) Never strike an electric arc on a gas cylinder and keep it clear of sparks, flames and electrical circuits. Arc burns can make the metal brittle and weaken the cylinder.

(3) Never tamper with cylinders in any way. Do not repaint them, change markings or identification, or interfere with valve threads or safety devices.

(4) Apart from the fact that it is illegal, it can be dangerous for non-specialists to refill cylinders or to change their contents. Explosions, cylinder contamination, or corrosion can result.

(5) Plastic fittings or tubing should not be used for any portion of a high-pressure system.

(6) Do not use Teflon tape on cylinder connections or tube-fitting connections because it could interfere with the fittings and cause leaks or clogging.

(7) Copper fittings or tubing, including bronze or brass ones containing more than 65% copper, should not be used on acetylene tanks – explosion may result. Acetylene also forms explosive compounds in contact with silver and mercury or their alloys.

(8) Ammonia attacks brass and can react with mercury to form an explosive compound. Do not use mercury pressure gauges in ammonia systems!

(9) Do not hang clothes or equipment over a compressed gas cylinder. Clothing can become saturated with a hazardous gas. If the gas is oxygen, clothing can catch fire and burn easily.

(10) Never interchange regulators and hose lines specifically for one kind of gas for another. Explosions can occur if flammable gases or organic materials come in contact with oxidizers (oxygen) under pressure.

(11) Never tamper with or attempt to alter cylinders, valves, or any safety relief device. Return cylinders to the supplier for all repairs.

9.0 Spill/Leak Response

Emergency response procedures are part of the university chemical safety program. Chemical hygiene plan (CHP) and emergency response procedures address the response actions to fires, explosions, spills, personal injury, and the development of signs and symptoms of overexposure.

If your skin or clothing becomes contaminated with gaseous or chemical vapors, check the SDS for appropriate decontamination procedures which generally include removal of contaminated clothing, use of emergency eyewash stations and body showers, and obtaining first aid or medical attention as appropriate.

Simple Gas or Vapor Leak
A "simple" compressed gas leak is one that involves minimal personal risk, such as a minimal inhalation hazard.

If the leak is at the junction of the cylinder valve and cylinder – do not try to repair it. Instead, contact the supplier and ask for appropriate response instructions. A leaking cylinder, regulator, or any other attached equipment should be taken out of service until the repair is completed.

If the cylinder contains a flammable, inert, or oxidizing gas, move it to a well-ventilated area such as a functioning fume hood, walk-in hood, or a secure outdoor area, if possible, away from incompatible materials. Allow it to remain isolated until the gas has discharged, making certain that the area is secured and appropriate warning signs have been posted.

If the cylinder contains a corrosive gas, remove the cylinder to an isolated, well-ventilated area away from incompatibles. The stream of reactive toxic gases or corrosive gases from reaction vessels should be passed through an appropriate gas absorber, such as charcoal based adsorbers and neutralizing traps.

Spill response for a simple corrosive gas spill should be developed before it is ever needed. Researchers should select gas specific neutralizing traps or gas absorbers to prevent an adverse reaction.

Major Gas or Vapor Leak
Call 911. Then, alert everyone in the area that a spill or release has occurred.

A "major" compressed gas leak is one that presents more than a minimal personal risk, and/or fire hazard, and/or is large and uncontrollable.

Do not attempt to handle a release of a toxic gas. Turn off ignition sources. Immediately vacate the area and ventilate the area only if it can be done safely. Remain on the scene at a safe distance to receive and direct emergency response personnel when they arrive.

10.0 Disposal

Non-returnable empty cylinders and bottles may be disposed of in general waste if the valve stem is removed. For gas cylinders with a Praxair label, contact Praxair at 1-800-283-8348. If there is no Praxair label contact Steve Stange, of University Surplus Equipment Operation, at 384-4045. Lecture bottles that are not empty, or have not had the valve stem removed, must be disposed of through EHS by completing the online hazardous waste pickup form

Appendix A – GHS classification of Commonly Used General Specialty Gases

Gas Type	Gas Name	UN No	Primary Hazard Classification	UN DG Code	Secondary Hazard Classification	Other Codes	GHS Signal Word	OSHA –GHS Pictogram			
General Gas	Acetylene, dissolved gas	1001	Flammable	2.1	None	2.1.1A	Danger				
General Gas	Air, compress gas	1002	Nonflammable	2.2	None		Warning				
General Gas	Argon, compressed gas	1006	Nonflammable	2.2	None		Warning				
General Gas	Argon, refrigerated liquid	1051	Nonflammable	2.2	None		Warning				
General Gas	Carbon dioxide, compressed gas	1013	Nonflammable	2.2	None		Warning				
General Gas	Carbon dioxide refrigerated liquid	2187	Nonflammable	2.2	None		Warning				
General Gas	Helium, compressed gas	1046	Nonflammable	2.2	None		Warning				
General Gas	Helium, refrigerated liquid	1963	Nonflammable	2.2	None		Warning				
General Gas	Hydrogen gas	1049	Flammable	2.1	None	2.1.1A	Danger				
General Gas	Nitrogen, compressed gas	1066	Nonflammable	2.2	None		Warning				
General Gas	Nitrogen, refrigerated liquid	1077	Nonflammable	2.2	None		Warning				
General Gas	Nitrous oxide, refrigerated liquid	2201	Non Flammable	2.2	Oxidizer	5.1.2A	Warning				
General Gas	Oxygen, compressed gas	1072	Non Flammable	2.2	Oxidizer	5.1.2A	Warning				
General Gas	Oxygen, refrigerated liquid	1073	Non Flammable	2.2	Oxidizer	5.1.2A	Warning				

Gas Type	Gas Name	UN No	Primary Hazard Classification	UN DG Code	Secondary Hazard Classification	Other Codes	GHS Signal Word	OSHA –GHS Pictogram			
Specialty Gas	Ammonia, anhydrous gas	1005	Toxic LC50: 400 ppmv	2.3	None	2.1.1B 6.1A 6.1.C	Danger				
Specialty Gas	Arsine, gas	2188	Toxic LC50: 120 ppmv	2.3	Flammable	2.1.1A 6.1A	Danger				
Specialty Gas	Boron trichloride	1741	Non Flammable	2.2	Corrosive	6.1C	Warning				
Specialty Gas	Boron trifluoride	1008	Toxic LC50: 400 ppmv	2.3	None	6.1A	Danger				
Specialty Gas	Butane	1011	Flammable	2.1	None	2.1.1A	Danger				
Specialty Gas	Carbon monoxide	1016	Toxic LC50: 3000 ppmv	2.3	Flammable	6.1C 2.1.1A	Danger				
Specialty Gas	Chlorine	1017	Toxic LC50: 290 ppmv	2.3	Oxidizer Corrosive	5.1.2A 6.1A	Danger				
Specialty Gas	Chlorine trifluoride	1749	Toxic LC50: 230 ppmv	2.3	Corrosive, Oxidizer	6.1A 5.1.2A	Danger				
Specialty Gas	Diborane	1911	Toxic LC50: 80 ppmv	2.3	Flammable	6.1A 2.1.1A	Danger				
Specialty Gas	Ethane, compressed gas	1035	Flammable	2.1	None	2.1.1A	Danger				
Specialty Gas	Ethylene, compressed gas	1962	Flammable	2.1	None	2.1.1A	Danger				
Specialty Gas	Ethylene oxide	1040	Toxic LC50: 800 ppmv	2.3	Flammable	6.1A 2.1.1A	Danger				
Specialty Gas	Hexafluoroethane, compressed gas	2193	Non Flammable	2.2	None		Warning				
Specialty Gas	Hydrogen chloride, anhydrous	1050	Non Flammable	2.2	Corrosive	6.1C	Warning				

Gas Type	Gas Name	UN No	Primary Hazard Classification	UN DG Code	Secondary Hazard Classification	Other Codes	GHS Signal Word	OSHA –GHS Pictogram			
Specialty Gas	Hydrogen fluoride, anhydrous gas	1052	Toxic LC50: 1270 ppmv	2.3	None	6.1A 6.1C	Danger				
Specialty Gas	Hydrogen sulfide	1053	Toxic LC50: 440 ppmv	2.3	Flammable	6.1.C 2.1.1A	Danger				
Specialty Gas	Isobutane	1069	Flammable	2.1	None	2.1.1A	Danger				
Specialty Gas	Krypton, compressed gas	1056	Nonflammable	2.2	None		Warning				
Specialty Gas	Methane Compressed gas	1971	Flammable	2.1	None	2.1.1A	Danger				
Specialty Gas	Neon, compressed gas	1065	Nonflammable	2.2	None		Warning				
Specialty Gas	Nitric oxide	1660	Toxic LC50: 130 ppmv	2.3	None	6.1A	Danger				
Specialty Gas	Nitrogen trifluoride	2451	Toxic LC50: 2000 ppmv	2.3	Oxidizer	6.1A 5.1.2	Danger				
Specialty Gas	Phosphine	2199	Toxic LC50: 10 ppmv	2.3	Flammable	6.1A 2.1.1A	Danger				
Specialty Gas	propane	1978	Flammable	2.1	None	2.1.1A	Danger				
Specialty Gas	Propylene	1077	Flammable	2.1	None	2.1.1A	Danger				
Specialty Gas	Silane	2203	Flammable	2.1	None	2.1.1A	Danger				
Specialty Gas	Sulfur dioxide	1079	Toxic LC50: 2500 ppmv	2.3	None	6.1C	Danger				

Gas Type	Gas Name	UN No	Primary Hazard Classification	UN DG Code	Secondary Hazard Classification	Other Codes	GHS Signal Word	OSHA –GHS Pictogram			
Specialty Gas	Sulfur hexafluoride	1080	Nonflammable	2.2	None		Warning				
Specialty Gas	Tetrafluoromethane	1982	Nonflammable	2.2	None		Warning				
Specialty Gas	Trifluoromethane	1984	Nonflammable	2.2	None		Warning				
Specialty Gas	Tungsten hexafluoride	2196	Toxic LC50: 110 ppmv	2.3	None	6.1A	Danger				
Specialty Gas	Vinyl chloride, liquefied gas	1086	Flammable LC50: 350 ppmv	2.1	Corrosive	2.1.1A	Danger				
Specialty Gas	Xenon, compressed gas	2036	Nonflammable	2.2	None		Warning				

Appendix B - DOT Class and Pictogram

UN/ DOT Class	Description	Pictogram
2.1.1A	2 = Gas. 1 = Flammable. 1A = High Hazard	
2.1.1B	2 = Gas. 1 = Flammable. 1B = Medium Hazard	
2.1.2A	2 = Gas. 1 = Flammable. 2A = Aerosol	
Class 2.2	2 = Gas. 2 = Non Flammable	
Class 2.3	2 = Gas. 3 = Toxic	
Class 5.1.2A	5.1 = Oxidizing substance. 2A = Gas	
Class 6.1A	6 = Toxic. 1 = Acutely toxic. A. An inhalation LC50 less than or equal to 100 PPM of the substance as gas in air by inhalation route. An oral LD50 less than or equal to 5 milligrams of the substance per kilogram of bodyweight	
Class 6.1B	6 = Toxic. 1 = Acutely toxic. B = LC50 100 – 500 PPM as a gas in air by inhalation route. An oral LD50 greater than 5 milligrams, but less than or equal to 50 milligrams of the substance per kilogram of bodyweight.	
Class 6.1C	6 = Toxic. 1 = Acutely toxic. C = An inhalation LC50 greater than 500 PPM, but less than or equal to 2500 PPM of the substance as gas in air by inhalation route. An oral LD50 greater than 50 milligrams, but less than or equal to 300 milligrams, of the substance per kilogram of bodyweight.	
Note: Gases may exhibit more than one hazard. Primary hazard classification column in the table is severe hazard for a particular gas. Additional hazards if any for a particular gas is listed in the secondary hazard classification column.		