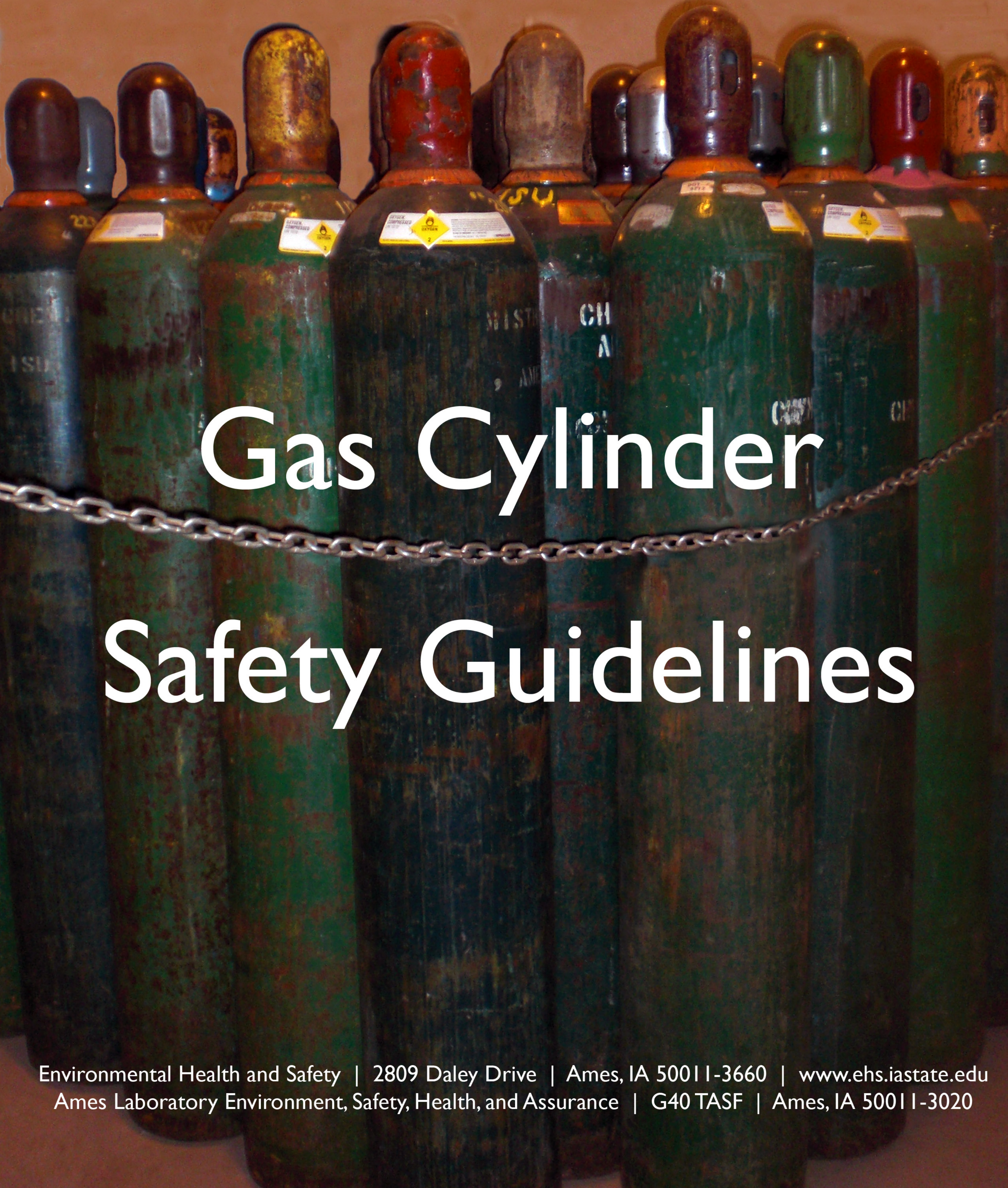
Iowa State University



Gas Cylinder Safety Guidelines

Environmental Health and Safety | 2809 Daley Drive | Ames, IA 50011-3660 | www.ehs.iastate.edu
Ames Laboratory Environment, Safety, Health, and Assurance | G40 TASF | Ames, IA 50011-3020

IOWA STATE UNIVERSITY

Environmental Health and Safety Statement

Iowa State University strives to be a model for environmental, health and safety excellence in teaching, research, extension, and the management of its facilities. In pursuit of this goal, appropriate policies and procedures must be developed and followed to ensure this community operates in an environment free from recognized hazards. Faculty, staff and students are responsible for compliance with established policies and are encouraged to enculturate practices that ensure safety, protect health and minimize the institution's impact on the environment.

As an institution of higher learning, Iowa State University

- fosters an understanding of and a responsibility for the environment;
- encourages individuals to be knowledgeable about environmental, health and safety issues that affect their discipline;
- shares examples of superior environmental health and safety performance with peer institutions, the State of Iowa and the local community.

As a responsible steward of facilities and the environment, Iowa State University

- strives to provide and maintain safe working environments that minimize the risk of injury or illness to employees, students and the public;
- continuously improves operations, with the goal of meeting or exceeding required and applicable environmental, health and safety regulations, rules, policies, or voluntary standards;
- employs innovative strategies of waste minimization and pollution prevention to reduce the use of toxic substances, promote reuse, and encourage the purchase of renewable, recyclable and recycled materials.

The intent of this statement is to promote environmental stewardship, protect health, and encourage safe work practices within the Iowa State University community. The cooperative efforts of the campus community to remain mindful of these goals will ensure that Iowa State University continues to be a great place to live, work and learn.

Dr. Steven Leath
President

University Nondiscrimination Statement

Last Revised: February 2013

DIRECTORY OF SERVICE AND EMERGENCY PROVIDERS

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2809 Daley Drive | 294-5359
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Ames Laboratory Environment, Safety, Health, and Assurance
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Thielen Student Health Center
Sheldon and Union Drive | 294-5801

McFarland Clinic Occupational Medicine
1018 Duff Avenue | 239-4496

Mary Greeley Medical Center (Emergency Room)
1111 Duff Avenue | 239-2011 or 911

Department of Public Safety
Armory | 294-4428 or 911 on campus

Occupational Medicine Office
G11 TASF | 294-2056

1. INTRODUCTION

Purpose and Scope

Compressed and liquefied gases are routinely used in laboratories and various other operations at Iowa State University. These *Guidelines* provide information on their safe use and apply to all Iowa State University employees who use or otherwise handle compressed or liquefied gases or systems that use compressed or liquefied gases.

Compressed and liquefied gases have the potential for creating hazardous working environments. Iowa State University promotes the safe use of gases by offering training and information on the proper storage, handling, use and disposal of compressed and liquefied gas cylinders. The information in these guidelines apply to all compressed and liquefied gases; however, specific information for selected hazard classes is contained in Section 6, Gases with Specific Hazards.

Personal Protective Equipment (PPE)

Standard laboratory PPE, including safety eye wear and a lab coat, are required when using compressed gases. Gloves may also be required, depending on the chemical or physical hazards of the gas. Additionally, when moving or transporting a gas cylinder, hard-toed shoes are required.

2. STORAGE

Proper storage is critical for the safe use of compressed and liquefied gases. Hazard information regarding the gases stored should be prominently posted in cylinder storage areas. The National Fire Protection Association (NFPA) 704 diamond, with a cylinder indicated in the "specific hazard" (white) section of the diamond and the corresponding flammability, health and reactivity hazard sections also marked, is an accepted method of signage. Other storage requirements are outlined below.

Requirements

Store gas cylinders:

- In an upright position.
- Within a well-ventilated area.
- Separate from empty cylinders.
- In the order in which they are received.
- With a chain or appropriate belt above the midpoint, but below the shoulder. Laboratory cylinders less than 18 inches tall may be secured by approved stands or wall brackets.
- With the cap on when not in use.
- So gases with the same hazard class are stored in the same area. Inert gases are compatible with all other gases and may be stored together.
- At least 20 feet away from all flammable, combustible or incompatible substances. Storage areas that have a noncombustible wall at least 5 feet in height and with a fire resistance rating of at least 30 minutes may be used to segregate gases of different hazard classes in close proximity to each other.

Do not store gas cylinders:

- In exits or egress routes.
- In damp areas; near salt, corrosive chemicals, fumes, heat; or exposed to the weather without a roof housing.
- Longer than one year without use.

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 1.

Table 1: Maximum Expanded Volume Quantity (ft^3) Limitations For Flammable or Toxic Compressed or Liquefied Gas Cylinders In Laboratories[(1)]*

	Ventilated Enclosure Sprinklered Room	Ventilated Enclosure Non-Sprinklered Room	Non-Ventilated Enclosure Sprinklered Room	Non-Ventilated Enclosure Non-Sprinklered Room
Highly Toxic [(2)]	40	20	No	No
Toxic / Corrosives [(2) (4)]	3240	1620	1620	810
Flammable [(3)]	4000	2000	2000	1000

Notes:

(1) Consult manufacturer or your safety office for expanded volume data for various sized cylinders.

(2) International Building Code (IBC) definition listed in Appendix I.

(3) Appendix II: Any material with a “y” in the flammability column (for materials classified as both flammable and toxic, defer to the toxic limitations).

(4) All ammonia storage containers must be stored and used in a ventilated enclosure, per EH&S requirement.

* 2006 International Building Code

Contact EH&S (294-5359) or ESH&A (294-2153) if you have cylinder use questions.

3. HANDLING

Compressed gases must be handled by properly trained persons. Training must include the contents in these guidelines as well as any specific information relevant to the gas being used. Training information is provided in Section 4 of these guidelines. Emergency information is outlined in the Laboratory Safety Manual and should be included in site specific training.

Requirements

To safely handle gas cylinders:

- **Never** drag or physically carry cylinders (lecture cylinders may be carried).
- **Never** pick up by the cap.
- **Never** paint a cylinder.
- **Never** leave cylinders in areas where they will be subject to damage from falling objects, corrosion or public tampering.
- **Never** subject cylinders to artificially created low temperatures without approval from the supplier.

Proper cylinder hand-truck

Lifting and moving requirements:

- Wear hard-toed shoes.
- **Do not** use ropes, chains and slings to suspend cylinders, unless the cylinder was designed for that use.
- **Do not** use magnets to lift cylinders.
- **Use** only suitable cradles or platforms to hold a cylinder when lifting.
- Use a hand-truck designed for the transport of cylinders.
- Secure cylinder caps during transport.
- **Vehicle Transport**
  - ◊ Only transport cylinders or cryogenic liquid containers in university vehicles.
  - ◊ Cylinders or cryogenic liquid containers must only be transported in a truck bed and properly secured.
  - ◊ Do not transport cylinders i cryogenic liquid containers n the passenger compartment of any vehicle.
- **Elevator Transport**
  - ◊ Do not accompany a compressed gas cylinder containing highly toxic gas on an elevator.
  - ◊ Place the cylinder in the elevator and press the destination floor.
  - ◊ Attach a sign to the cylinder, telling others not to use the elevator during the cylinder's trip.

4. TRAINING

General Lab Safety: Compressed Gas Cylinder Training is available online. Completion of the online training course and a review of this manual will help ensure that gas cylinders are safely used. An overview of specific health or safety concerns related to a gas use should be part of site specific training. As with any chemical, read the gas's safety data sheet before you begin using the gas.

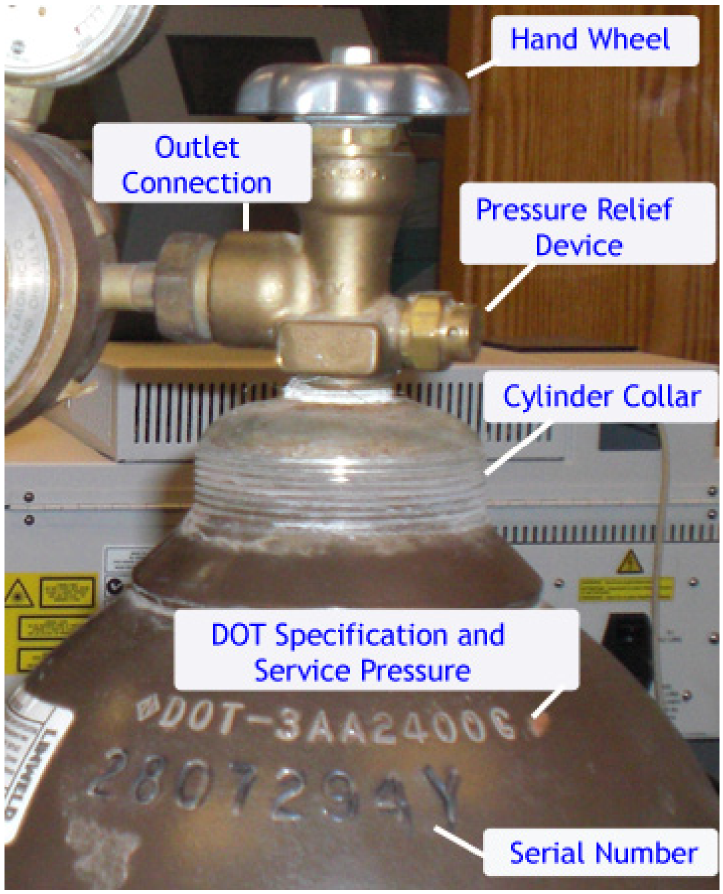
Gas cylinders are used in various areas within the university, including mechanical shops and laboratories. Online training for laboratory employees is Lab Safety: Fundamental Concepts. Course completion is required for employees working in laboratories.

5. GENERAL USE REQUIREMENTS

Use Requirements

To safely use valves and regulators:

- Be sure the regulator pressure control valve is relieved (i.e., closed) before attaching it to cylinders.
- **Do not** stand in-line with the regulator and valve outlet when attaching the regulator to the cylinder.
- Close valves on gas cylinders when a system is not in use.
- Remove all pressure from regulators not currently used (by opening equipment valves downstream after the regulators are closed).
- **Do not** install shut-off valves between pressure relief devices and the equipment they protect.
- Use pressure relief valves in downstream lines to prevent high pressure buildup in the event that a regulator valve does not seat properly and a tank valve is left on.
- Vent relief valves to a fume hood or ventilated gas cabinet, when using flammable or toxic gases.
- Pressurize regulators slowly and ensure that valve outlets and regulators are pointed away from all personnel when cylinder valves are opened.
- Leave the wrench in place on the cylinder valve, when needed, to open the main valve. Use adequately sized wrenches (12 inches long) to minimize ergonomic stress when turning tight tank valves. Cylinders with "stuck" valves should be returned to suppliers to have valves repaired.
- Fully open valves during cylinder use. A fully open valve improves the internal seal and helps prevent packing leaks.
- Use a cylinder cap hook to loosen tight cylinder caps. Never apply excessive force to pry off caps. Return a cylinder to the supplier to remove "stuck" caps.



To safely use gas cylinders:

- **Never** apply excessive force when trying to open valves.
- **Never** allow flames or concentrated heat sources to come in contact with a gas cylinder.

- **Never** allow a gas cylinder to become part of an electrical circuit.
- **Never** partially open a cylinder valve to remove dust or debris from the cylinder inlet.
- **Never** use cylinder gas as a compressed air source.
- **Never** use adapters or exchange fittings between tanks and regulators.
- **Never** use Teflon™ tape on Compressed Gas Association (CGA) fittings (straight thread) where the seal is made by metal-to-metal contact. Use of Teflon™ tape causes the threads to spread and weaken, increasing the likelihood of leaks. Small pieces of tape can also become lodged in the valve mechanism resulting in possible valve failure.
- **Never** attempt to open a corroded valve; it may be impossible to reseal or it may break and release the cylinder's contents.

System Construction

The following information applies to the use of manifolds, piping, valves and/or regulators:

- Where compressed gas cylinders are connected to a manifold, the manifold and its related equipment, such as regulators (see Appendix IV), must be of proper design for the product(s) they are to contain at the appropriate temperatures, pressures and flows.
- Use only approved valves, regulators, manifolds, piping, and other associated equipment in any system that requires compressed gas.
  - ◊ Be sure pressure gauges on regulators are correct for the pressure of the gas cylinder used.
  - ◊ Gas threads, configurations and valve outlets are different for each class of gases to prevent mixing of incompatible gases. Lecture bottles are an exception.
- Lecture bottles use universal threads and valves, some of which are interchangeable. Label all associated equipment with the gas name, to prevent unintentional mixing of incompatible materials.
- Compressed Gas Association Pamphlet V-1: "Standard for Compressed Gas Cylinder Valves," lists the appropriate valve for each gas. Manufacturers and distributors should also be able to identify the valves and associated equipment required for each gas.
- Contact EH&S (294-5359) or ESH&A (294-2153) with cylinder use questions.

System Maintenance

The following information applies to the use of system piping, regulators, manifolds and other apparatuses:

- Keep piping, regulators and other apparatuses gas tight to prevent gas leaks.
- Confirm the connection seal by using compatible leak test solutions (e.g., soap and water) or leak test instruments.
- Release pressure from systems before connections are tightened or loosened and before any repairs.
- Fluorescent light can be used to check for grease or oil in regulators and valves.
- **Valve and Regulator Maintenance**
  - ◊ Know the valve and regulator maintenance histories before use.

◊ Valves and regulators should undergo periodic maintenance and repair as necessary.

◊ Perform a visual inspection before each use to detect any damage, cracks, corrosion, or other defects.

◊ Valves that pass visual inspection are still subject to failure. It is critical that toxic or poisonous gases (see Appendix II) are used in ventilated enclosures and have local exhaust ventilation in place for downstream pressure relief valves.

◊ Long term maintenance or replacement periods vary with the types of gases used, the length of use, and conditions of use. Consult the cylinder, regulator or gas supplier for recommended valve and regulator maintenance schedules.

◊ Valves and regulators should only be repaired by qualified individuals. Consult valve and regulator manufacturers, gas supply companies, or valve and regulator specialty shops for any repair needs.

Labeling

The following labeling requirements apply to all gas cylinders:

- Use only the vendor label for positive identification of contents of the cylinder. Be aware that color coding may be inconsistent from vendor to vendor.
- Mixed gases must be clearly labeled with the contents of the cylinder.
- Empty cylinders must be labeled with the word “empty.”
- Know the contents of each cylinder you are using. Preferred labeling includes the identity of the material, statement of hazard and the associated signal word. For example, the preferred label for nitrogen would be:

Use these sources of information for the warning and hazard information required on cylinders:

- Air Products,
- Matheson and other gas company catalogs,
- The CGA Pamphlet C-7: “Precautionary Labeling and Marking of Compressed Gas Cylinders,”
- The manufacturer or distributor of the gas.

Contact EH&S (294-5359) or ESH&A (294-2153) with cylinder use questions.

Other Requirements

- Only the gas supplier is allowed to mix gases in a cylinder.
- Do not use cylinders for any other purpose than holding the contents as received. Damaged or leaking cylinders must be reported to EH&S or ESH&A immediately.
- Leaking, defective, fire burned, or corroded containers must not be shipped without the prior approval of the supplier.

6. SPECIFIC HAZARD CLASSES

This section provides additional guidance to be used in conjunction with the general use requirements listed in Section 4.

Corrosive Gases

Examples include chlorine, hydrogen chloride, fluorine, hydrogen fluoride, and hydrogen sulfide.

- Remove regulators after use and flush with dry air or nitrogen.
- Metals become brittle when used in corrosive gas service; check equipment and lines frequently for leaks.
- Use a diaphragm gauge with corrosive gases that would destroy a steel or bronze gauge. Check with the gas supplier for recommended equipment.

Cryogenic Liquids and Gases

Cryogenic liquids and their boil-off gases rapidly freeze human tissue and cause embrittlement of many common materials. All cryogenic liquids produce large volumes of gas when they vaporize and may create oxygen-deficient conditions. Examples of common cryogenic liquids include liquid oxygen, hydrogen, helium, and liquid neon. The following information applies to the use and handling of cryogenics:

- Use appropriate personal protective equipment, including insulated gloves, lab coat and eye protection (goggles and a face shield) during any transfer of cryogenic liquid.
- In the event of skin contact with a 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]). If a burn is significant, seek medical attention.
- Use only equipment, valves and containers designed for the intended product, service pressure and temperature.
- 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.

Courtesy of NASA

- Transfer operations involving open cryogenic containers, such as dewars, must be conducted slowly to minimize boiling and splashing of the cryogenic fluid.
- 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.
- All cryogenic systems, including piping, must be equipped with pressure relief devices to prevent excessive pressure build-up. Pressure reliefs must be directed to a safe location. Do not tamper with pressure relief valves or the settings for the valves.

- Hot air, steam or hot water should be used to thaw frozen equipment. Exception: **Do not** use water to thaw liquid helium equipment.
- For vehicle transportation, cryogenic liquid containers must only be transported in a university truck bed and not within a vehicle's passenger.

Flammable Gases

Some common examples of flammable gases include acetylene, hydrogen, methane, propane, carbon monoxide, and isobutane. See Appendix II for a list of flammable gases.

- Flammable gases, except for protected fuel gases, must not be used near ignition sources. Ignition sources include open flames and sparks, sources of heat, oxidizing agents and ungrounded or non-intrinsically safe electrical or electronic equipment.
- Portable fire extinguishers must be available for fire emergencies. The fire extinguisher must be compatible with the apparatus and the materials in use. Contact EH&S to be sure an appropriate fire extinguisher is being used for a specific gas.
- **Do not** use flames for detecting leaks. A compatible leak detection solution must be used for leak detection.
- Use spark-proof tools when working with or on a compressed gas cylinder system containing flammable gases
- Post "No Open Flames" signage on access doors to areas that use or store flammable gases.
- Manifold systems must be designed and constructed by competent personnel who are familiar with the requirements for piping of flammable gases. Consultation with the gas supplier before installation of manifolds is recommended.

Fuel, High Pressure and Oxidizing Gases

Fuel gases often use a combination of flammable and oxidizing gases. Use of fuel gases must comply with,

- OSHA 29 CFR1910.253--Oxygen-Fuel Gas Welding and Cutting
- 29 CFR1910.102--Acetylene
- 29 CFR1910.103--Hydrogen
- Compressed Gas Association (CGA) Pamphlet G-1: "Acetylene"
- CGA Pamphlet SB-8: "Use of Oxy-fuel Gas Welding and Cutting Apparatus"
- NFPA Standard 51: "Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting and Allied Processes."

High pressure gases can be rated up to 3,000 pounds per square inch (psi). Typical uses for high pressure gases include:

- Inert welding gas mixtures
- Cryogenics

- Non-toxic gas distribution
- Medical gas distribution
- Emergency oxygen services

In addition to any gas-specific hazards, high pressure gases should carry a caution label

Oxidizing gases are non-flammable. Oxidizing gases, but in the presence of an ignition source and fuel can support and vigorously accelerate combustion include:

- Oxygen
- Chlorine
- Fluorine
- Nitrous oxide

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."

Toxic and Highly Toxic Gases

Common toxic or highly toxic gases are listed in Appendix II.

- Some gases, depending on their toxicity and expandable quantities, must be stored in a continuously ventilated gas cabinet, fume hood or other enclosure. Storage quantities are listed in Section 2, Table 1.
- Small quantities (e.g., lecture cylinders), or dilute concentrations of these gases may be stored outside of a ventilated enclosure with prior approval of EH&S or ESH&A.
- Use audible alarms in ventilated hoods or gas cabinets that are dedicated to toxic gas usage or storage.
- Standard operating procedures for processes that use corrosive, toxic or highly toxic gases must be developed and include emergency response actions. All affected personnel must be trained on these procedures.

7. DISPOSAL

Identification and Disposal

- Proper identification of the contents of all cylinders is required and is the responsibility of the cylinder owner.
- Maintain manufacturer labels on cylinders. If a cylinder is empty, label the cylinder with an "Empty" tag.
- Whenever possible, purchase compressed gas from ISU Chemistry Stores or Ames Laboratory Purchasing. Vendors must be able to accept an empty cylinder.
- Refillable cylinders should be returned to Chemistry Stores, materials handling personnel, or directly to the vendor. Return cylinders with at least 30 pounds of pressure to reduce the risk of foreign materials entering the empty vessel.
- If a refillable cylinder is encountered that does not have a manufacturer label, contact Chemistry Stores or materials handling personnel, to see if they can identify the manufacturer through stamp marks on the cylinder.
- Lecture cylinders must be returned at atmospheric pressure. Empty lecture cylinders may be given to EH&S or ESH&A.
- EH&S or EHS&A should be contacted for disposal of partially full cylinders or unwanted full cylinders.
- Disposal fees for unknown cylinders are a departmental expense.

8. LEAKS AND EMERGENCIES

Pre-Planning

Despite adherence to cylinder safety practices, accidents involving gases may occur. The amount of damage sustained by personnel and property from these accidents is greatly influenced by the quality of the emergency plan. Users of compressed gas cylinders must be familiar with necessary safety precautions. SOPs for using compressed gases must include a discussion of possible accident scenarios, appropriate employee responses and should take into account the following factors:

- The nature of the operation (e.g., experimental design, equipment used and type of injury that could occur.
- The potential location of a release or spill (e.g., outdoors versus indoors, in a laboratory, corridor or storage area, on a table, in a hood, or on the floor).
- The quantities of material that might be released and the type of containment (i.e., compressed gas tank size, manifold systems, etc.).
- The chemical and physical properties of the compressed gas (e.g., its physical state, vapor pressure and air or water reactivity).
- The hazardous properties of the compressed gas (e.g., its toxicity, corrosivity and flammability).
- The availability and locations of emergency supplies and equipment.
- An Emergency Action Plan that identifies building evacuation routes, emergency telephone numbers, chemical containment procedures, fire extinguisher usage, etc.

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, or the valve outlet. To correct minor leaks:

- For non-toxic gases, verify suspected leaks using a 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, notify EH&S or Ames Laboratory ESH&A. **Do not** try to fix a leak on a toxic or highly toxic gas cylinder; instead initiate emergency action procedures.
- For flammable (non-toxic), inert or oxidizing gases (non-toxic), move the cylinder to an isolated, well-ventilated area (within or next to a fume hood), away from combustible materials. **Post signs** that describe the hazard.
- For corrosive and toxic gas leaks, immediately contact EH&S or Ames Laboratory ESH&A for leak remediation or cylinder removal. Leave the laboratory until EH&S or Ames Laboratory ESH&A corrects the leak or removes the cylinder from the lab. **Do not** remove a leaking toxic gas cylinder from a ventilated cabinet.

Major Leaks

In the event of a large gas release or if an accident takes place, activate the following emergency procedures:

1. Evacuate the area, securing entrances and providing assistance to others on the way out.
2. Activate building and area fire alarms (or chemical safety alarms if applicable).
3. Immediately call 911 and report the incident.
4. Provide emergency response officials with details of the problem upon their arrival. The Ames Fire Department will respond to all chemical emergencies at Iowa State University.

Accidents Involving Personnel Injury

- For medical emergencies call 911.

- Assist persons involved and administer immediate first aid, which may include:
    - ◊ Washing under a safety shower (in case of burning clothing or chemical exposures)
    - ◊ Removing contaminated clothing
    - ◊ Irrigating the eyes at an eyewash station
    - ◊ Administering cardiopulmonary resuscitation (CPR)
- Notify personnel in adjacent areas of any potential hazards (e.g., activate building or area alarms).
- Move injured personnel only if necessary to prevent further harm.

Fire and Fire-Related Emergencies

For all fire, 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 the [Fire Safety Guidelines]. For large or rapidly spreading fires, the following procedures should be followed:

- Activate building and area alarms.
- Call 911 to report the fire.
- Evacuate the building, shutting doors and providing assistance to others on the way out.
- Provide fire or police officials with the details of the problem upon their arrival.

I. APPENDIX

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 is 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 material that is a gas at 68° F (20°C) or less at 14.7 pounds per square inch atmosphere (psia) (101 kPa) of pressure [a material that has a boiling point of 68°F (20°C) or less at 14.7 psia (101 kPa)] which:

Is ignitable at 14.7 psia (101 kPa) when in a mixture of 13 percent or less by volume with air; or

Has a flammable range at 14.7 psia (101 kPa) with air of at least 12 percent, regardless of the lower limit.

The limits specified shall be determined at 14.7 psi (101 kPa) of pressure and a temperature of 68°F (20°C) in accordance with ASTM E 681.

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 material which produces a lethal dose concentration that falls within any of the following categories:

A chemical that has a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

A chemical that has a median lethal dose (LD_{50}) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

A chemical that has a median lethal concentration (LC_{50}) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

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 (40psi) 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 chemical falling within any of the following categories:

A chemical that has a median lethal dose (LD_{50}) of more than 50 milligrams per kilogram, but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

A chemical that has a median lethal dose (LD_{50}) of more than 200 milligrams per kilogram but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

A chemical that has a median lethal concentration (LC_{50}) in air of more than 200 parts per million but not more than 2,000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

II. APPENDIX

Common Compressed and Liquefied Gases that are Flammable or Toxic (Health 3 or 4)*

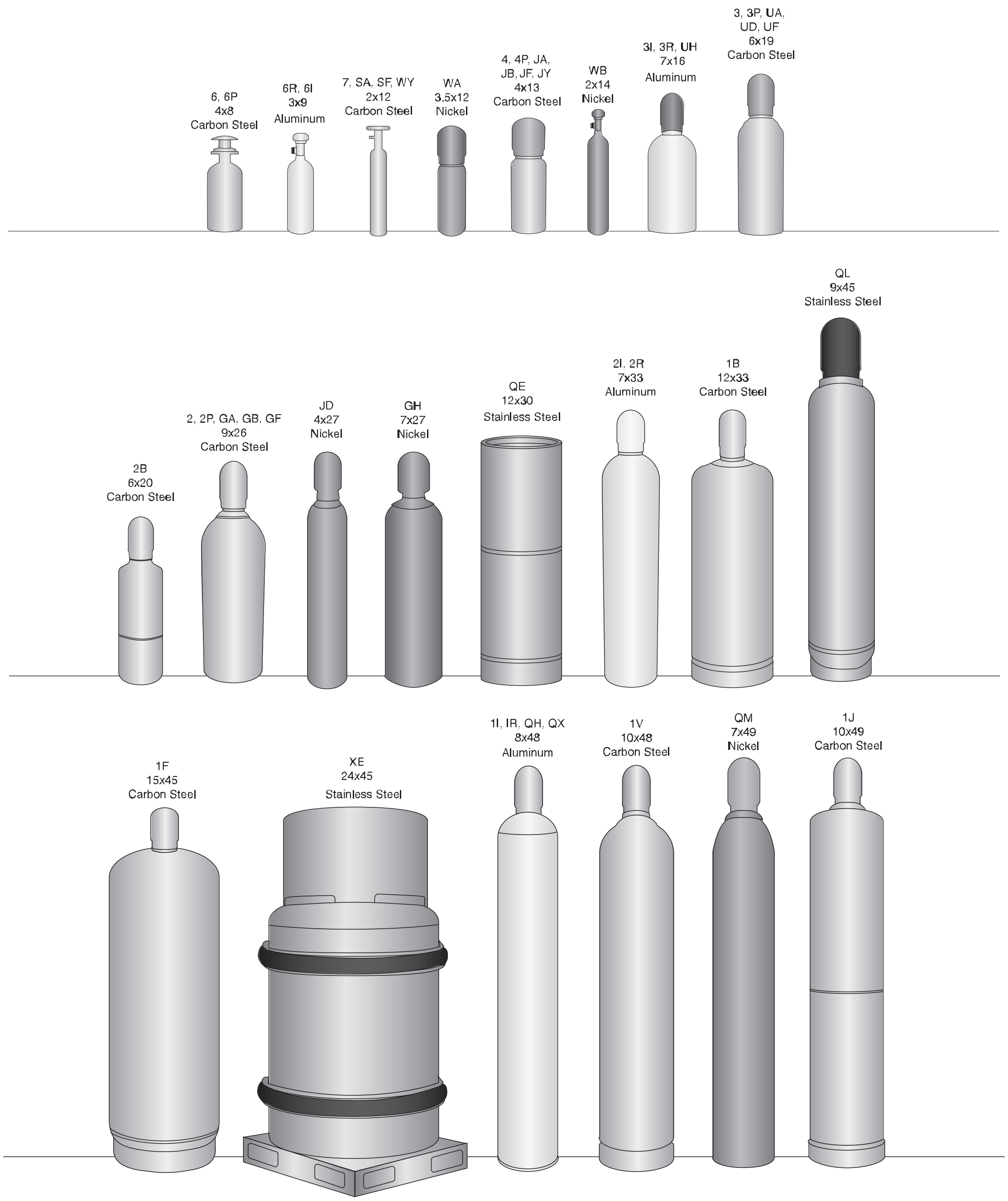
Gas	State	Flammable	Health
Acetylene	gas	y	
Allene (propadiene)	liquid	y	
Ammonia	liquid	y	3
Arsine	liquid	y	4
Boron Trichloride	gas	n	3
Boron Trifluoride	gas	n	3
1,3-Butadiene	liquid	y	
n-Butane	liquid	y	
iso-Butane	liquid	y	
1-Butene	liquid	y	
2-Butene	liquid	y	
Carbon Monoxide	gas	y	3
Carbonyl Chloride (phosgene)	gas	n	4
Carbonyl Fluoride	gas	n	4
Carbonyl Sulfide	liquid	y	3
Chlorine	gas	n	3
Chlorine Dioxide	gas	n	4
Chlorine Monoxide	gas	y	3
Chlorine TriFluoride	gas	n	4
1-Chloro-1,1-difluoroethane	liquid	y	
Chlorotrifluoroethylene	liquid	y	
Cyanogen	liquid	n	4
Cyanogen Chloride	liquid	n	4
Cyclobutane	gas	y	
Cyclopropane	liquid	y	
Deuterium	gas	y	
Diazomethane	gas	y	4
Diborane	gas	spontaneously ignitable	3
1,1-Difluoroethane	liquid	y	
1,1-Difluoroethylene	liquid	y	3
Dimethylamine	gas	y	3
Dimethyl Ether	liquid	y	
2,2-Dimethylpropane	liquid	y	
Ethane	gas	y	
Ethylacetylene	liquid	y	
Ethylamine	liquid	y	3
Ethyl Chloride	liquid	y	
Ethylene	gas	y	
Ethylene Oxide	liquid	y	3
Fluorine	gas	n	4
Formaldehyde	gas	y	3
Germane	gas	y	
Hexafluoroacetone	gas	n	3
Hydrogen	gas	y	

Gas	State	Flammable	Health
Hydrogen Bromide	gas	n	3
Hydrogen Chloride	gas	n	3
Hydrogen Cyanide	liquid	y	4
Hydrogen Fluoride	gas	n	4
1,1-Difluoroethane	liquid	y	
Hydrogen Selenide	liquid	y	3
Hydrogen Sulfide	liquid	y	4
Ketene	gas	y	
Methane	gas	y	
Methylacetylene (propyne)	liquid	y	
Methylamine	liquid	y	3
Methylbromide	liquid	y	3
3-Methyl-1-butene	liquid	y	
Methyl Chloride	liquid	y	
Methyl Ether	gas	y	
Methyl Fluoride	liquid	y	
Methyl Mercaptan	liquid	y	4
2-methylpropene	gas	y	
Natural Gas	gas	y	
Nitric Oxide	gas	n	3
Nitrogen Dioxide	gas	n	3
Nitrogen Trioxide	gas	n	3
Nitrogen Trifluoride	gas	n	3
Nitrosyl Chloride	gas	n	3
Oxygen Difluoride	gas	n	4
Ozone	gas	n	4
Pentaorane	liquid	spontaneously ignitable	4
iso-Pentane	liquid	y	
Phosphine	gas	spontaneously flammable	4
Propane	liquid	y	
Propylene	liquid	y	
Selenium Hexafluoride	gas	n	3
Silane	gas	spontaneously flammable	
Silicon Tetrafluoride	gas	n	4
Stibine	gas	y	4
Sulfer Tetrafluoride	gas	n	4
Sulfuryl Fluoride	gas	n	
Tetrafluorioethylene, monomer	liquid	y	
Tetrafluorohydrazine	liquid	y	
Trimethylamine	liquid	y	3
Vinyl Bromide	liquid	y	
Vinyl Chloride	liquid	y	
Vinyl Fluoride	liquid	y	
Vinyl Methyl Ether	liquid	y	

III. APPENDIX

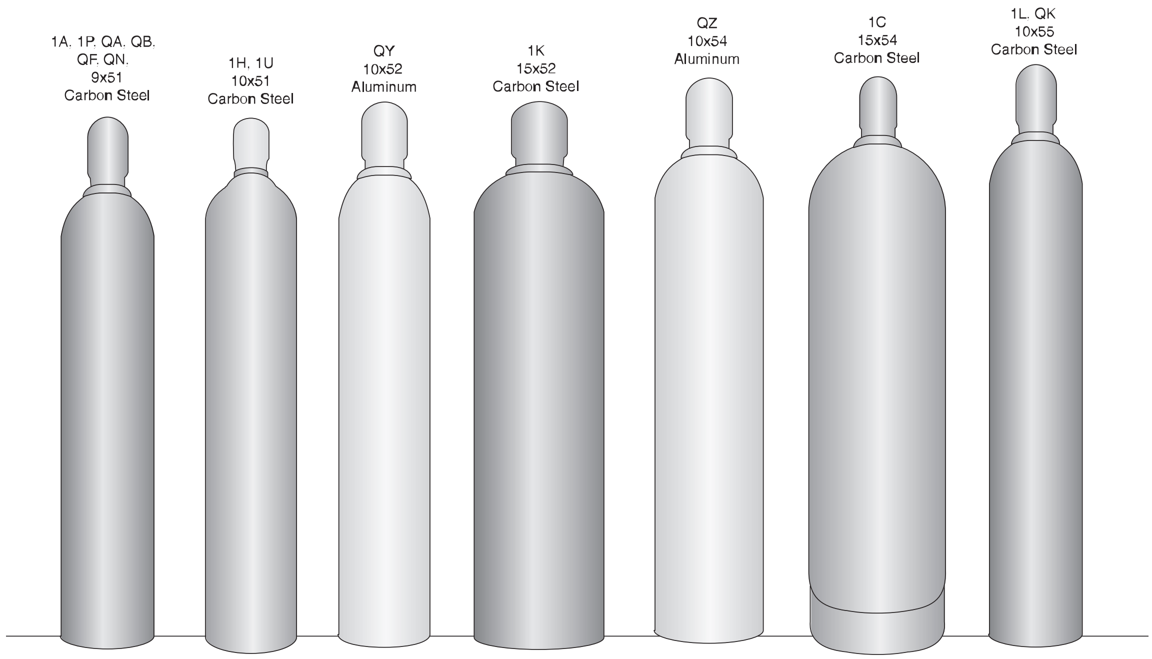
Cylinder Types

Cylinder Diagrams

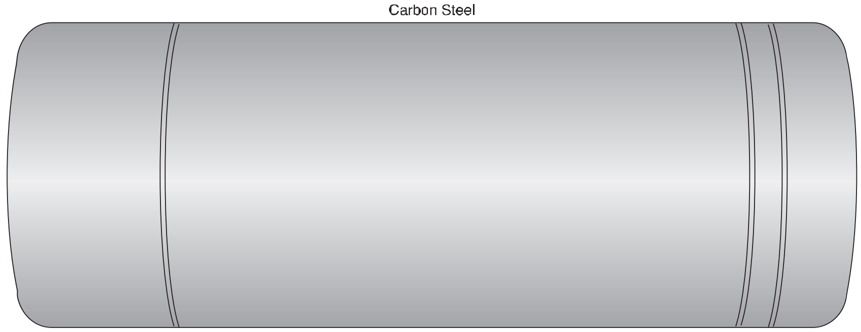


* National Fire Protection Association health ratings

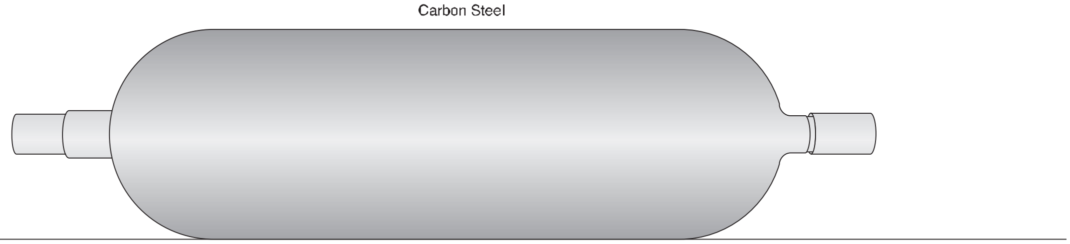
Cylinder Diagrams *(continued)*



Multi Unit Tank Cor Tank
(Used for H_2S, Cl_2, NH_3, and other gases)
30x81
Carbon Steel



1T, QI, Ton Container
(Used for HCl and other gases)
24x83
Carbon Steel



Cylinder Comparison Chart

Matheson Tri-Gas	Nominal Dimensions (inches)	Material of Construction	Air Products	Air Liquide	BOC	Praxair	Scott
1L/QK	10x55	C	A	49	300	UCT	K
1A/QA	9X51	C	B	44	200	K	A
1R/QX	8X48	A	B (AL)	30AL	150A	AS	AL
2/GA	9X26	C	C	16	80	Q	B
2R/GX	7X33	A	C(AL)	22AL	80A	AQ	BL
3/UA	6X19	C	D-1	7	30	G	C
3R/UX	7X16	A	D-1(AL)	7AL	30A	AG	CL
4/JA	4X13	C	D	3	12	F	D
LB	2X12	C	LB	LB	LB	LB	LB

IV. APPENDIX

Valve Types

Gas	CGA Valve Outlet & Conn. No. CGA/UHP CGA
Acetylene	510
Air, Breathing	346
Air, Industrial	590*
Allene	510**
Ammonia, Anhydrous	705**
Ammonia, Electronic	660/720
Argon	580*/718
Argon-3500 psig	680***
Argon-6000 psig	677
Arsine	350/632
Boron Trichloride	660**/634
Boron Trifluoride	330**/642
1,3-Butadiene	510*
Butane	510*
Butenes	510*
Carbon Dioxide	320*/716
Carbon Monoxide	350*/724
Carbonyl Fluoride	660
Carbonyl Sulfide	330**
Chlorine	660/728**
Cyanogen	660
Cyanogen Chloride	660
Cyclopropane	510*
Deuterium	350*
Dichlorosilane	678/636
Dimethylamine	705**
Dimethyl Ether	510*
2,2-Dimethylpropane	510
Disilane	350/632*
Ethane	350*
Ethyl Chloride	300*
Ethylene	350*
Ethylene Oxide	510**
Fluorine	679

Gas	CGA Valve Outlet & Conn. No. CGA/UHP CGA
Germane	350/632
Halocarbon 12 (Dichlorodifluoromethane)	660*/716
Halocarbon 13 (Chlorotrifluoromethane)	660/716
Halocarbon 13B1 (Bromotrifluoromethane)	660
Halocarbon 14 (Tetrafluoromethane)	320*/716
Halocarbon 23 (Fluoroform)	660/716
Halocarbon 114 (2,2-Dichlorotetrafluoroethane)	660*/716
Halocarbon 115 (Chloropentafluoroethane)	660*/716
Halocarbon 116 (Hexafluoroethane)	660/716
Halocarbon 142B (1-Chloro-1,1-difluoroethane)	510
Halocarbon 1113 (Chlorotrifluoroethylene)	510
Helium-3500 psig	680***
Helium	580*/718
Hexafluoropropylene	660*
Hydrogen	350*/724
Hydrogen-3500 psig	695***
Hydrogen Bromide	330**/634
Hydrogen Chloride	330**/634
Hydrogen Fluoride	660**/638
Hydrogen Selenide	350/632
Hydrogen Sulfide	330**/722
Isobutane	510*
Isobutylene	510*
Krypton	580/718

Gas	CGA Valve Outlet & Conn. No. CGA/UHP CGA
"Manufactured Gas B"	350
Methane	350*
Methyl Bromide	330
3-Methyl-1-butene	510
Methyl Chloride	660*
Methyl Fluoride	350
Methyl Mercaptan	330**
Monomethylamine	705**
Neon	580*/718
Nitric Oxide	660/712
Nitrogen	580*/718
Nitrogen-3500 psig	680***
Nitrogen-6000 psig	677
Nitrogen Dioxide	660
Nitrogen Trioxide	660
Nitrous Oxide	326*/712
Octafluorocyclobutane	660*
Oxygen	540*/714
Oxygen Mixtures Over 23.5%	296
Perfluoropropane	660*/716
Phosgene	660
Phosphine	350/632
Phosphorus Pentafluoride	660**
Propane	510*
Propylene	510*
Silane (High Pressure)	350/632
Silicon Tetrafluoride	330**/642
Sulfur Dioxide	660**
Sulfur Hexafluoride	590*/716
Trimethylamine	705**
Vinyl Bromide	510
Vinyl Methyl Ether	510
Xenon	580**/718

**Lecture bottles use CGA No. 170*
***Lecture bottles use CGA No. 180*
****For information on CGA 680 and 695 connections contact your nearest Matheson Tri-Gas office.*

**, **NOTE: The CGA 170 is authorized for non-corrosive gases packaged in lecture bottles. The CGA 180 is authorized for all gases packaged in lecture bottles.*