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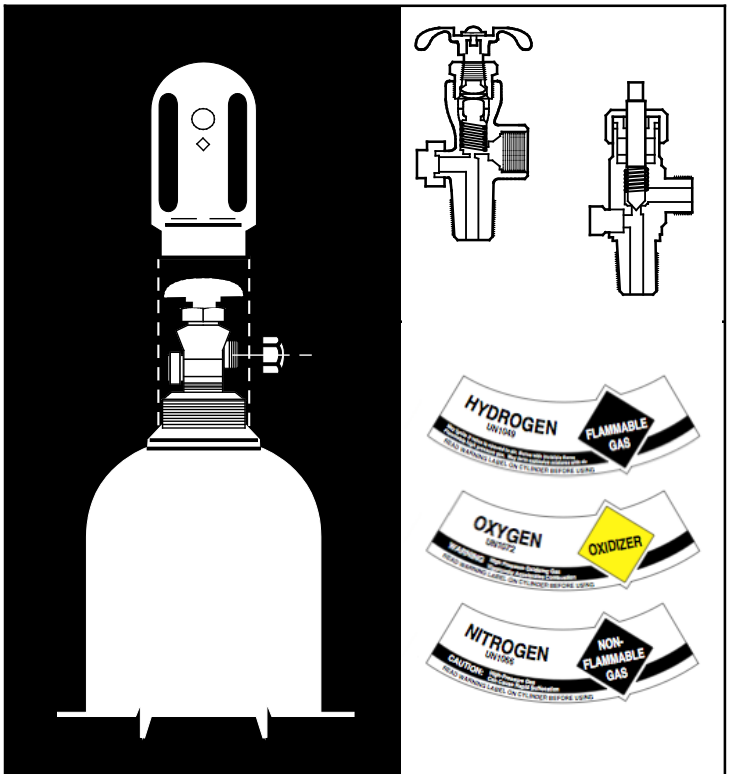
Gas Cylinder Safety

Course 9518



February 2017

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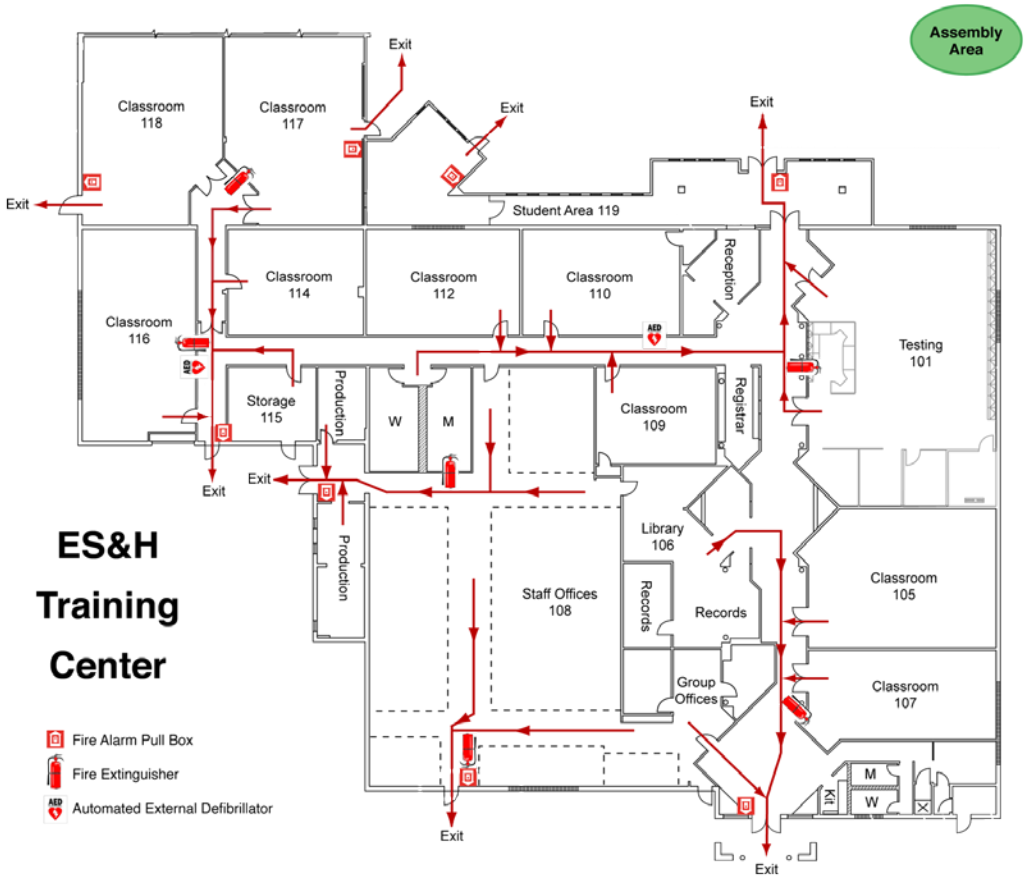

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Introduction

Course Overview

This course, *Gas Cylinder Safety* (#9518), presents an overview of the hazards and controls associated with handling, storing, using, and transporting gas cylinders. Standard components and markings of gas cylinders are also presented, as well as the process for the procurement, delivery, and return of gas cylinders at Los Alamos National Laboratory (LANL).

Course Objectives

Terminal Objective

Upon completion of this course, you will be able to work safely with gas cylinders at LANL by recognizing hazards and controls associated with their handling, use, storage, and transport.

Enabling Objectives

When you have completed this course, you will be able to

- identify gas cylinder specification markings;
- identify components common to gas cylinders;
- recognize that specific gas cylinder connections are determined by the family of gas that a cylinder contains;
- recognize general hazards associated with gas cylinders, including pressure and oxygen-deficiency;
- recognize hazards resulting from the size and weight of some gas cylinders;
- recognize hazards associated with the contents of gas cylinders;
- recognize engineering and safe work practices for gas cylinder storage, handling, and use;
- recognize controls for gas cylinder content hazards;
- recognize personal protective equipment (PPE) for gas cylinder handling and use;
- recognize safe work practices and labeling and placarding requirements for gas cylinder transport;

- recognize the process for the procurement, delivery, and return of gas cylinders at LANL;
- recognize the steps to take in the event of an accidental or uncontrolled release of a gas cylinder; and
- identify resources for gas cylinder information and assistance.

Target Audience

This course is required by LANL P101-34, *Pressure Safety*, for personnel who work with gas cylinders.

Prerequisites

Pressure Safety Orientation (#769).

Course Limitations

This course does not address

- every type of hazard that may be associated with gas cylinders, nor does it eliminate the need for site-specific training;
- the hazards of specific gases; or
- facility-specific procedures for the handling, storage, transport, or use of gas cylinders, nor the facility-specific responses to a gas cylinder event.

Acronyms

CFR	Code of Federal Regulations
CGA	Compressed Gas Association
DOT	Department of Transportation
HMTF	Hazardous Material Transfer Form
IDLH	immediately dangerous to life and health
LANL	Los Alamos National Laboratory
MAPP	methylacetylene propadiene
MAWP	maximum allowable working pressure
SDS	safety data sheet
PPE	personal protective equipment
ppm	parts per million
psi	pounds per square inch
PSIA	pounds per square inch absolute
PSIG	pounds per square inch gauge
RFO	restrictive flow orifice
RMTF	Radioactive Material Transfer Form

Module 1: Gas Cylinder Markings and Components

Module Overview

To work safely with gas cylinders, you should understand cylinder markings, construction, and function. By using the correct components and connections for a particular gas and/or pressure to segregate materials that can react with each other, you will decrease the possibility of cylinder-related accidents significantly.

Module Objectives

When you have completed this module, you will be able to

- identify gas cylinder specification markings,
- identify components common to gas cylinders, and
- recognize that specific gas cylinder connections are determined by the family of gas that a cylinder contains.

Gas Cylinder Specifications

A compressed gas is a gas stored and used at pressures greater than normal atmospheric pressure. Compressed gases are packaged and transported in cylinders manufactured and tested in accordance with Department of Transportation (DOT) regulations and Compressed Gas Association (CGA) guidelines.

Cylinders commonly used indoors for compressed gases range in length from less than 2 feet to approximately 5 feet. Several factors determine the cylinder size to be used for a particular task, including the

- volume of gas needed,
- means of delivery,
- available storage space, and
- safety issues.

Much larger cylinders, up to 40 feet long and collectively called “tube bundles,” are used to supply bulk quantities.

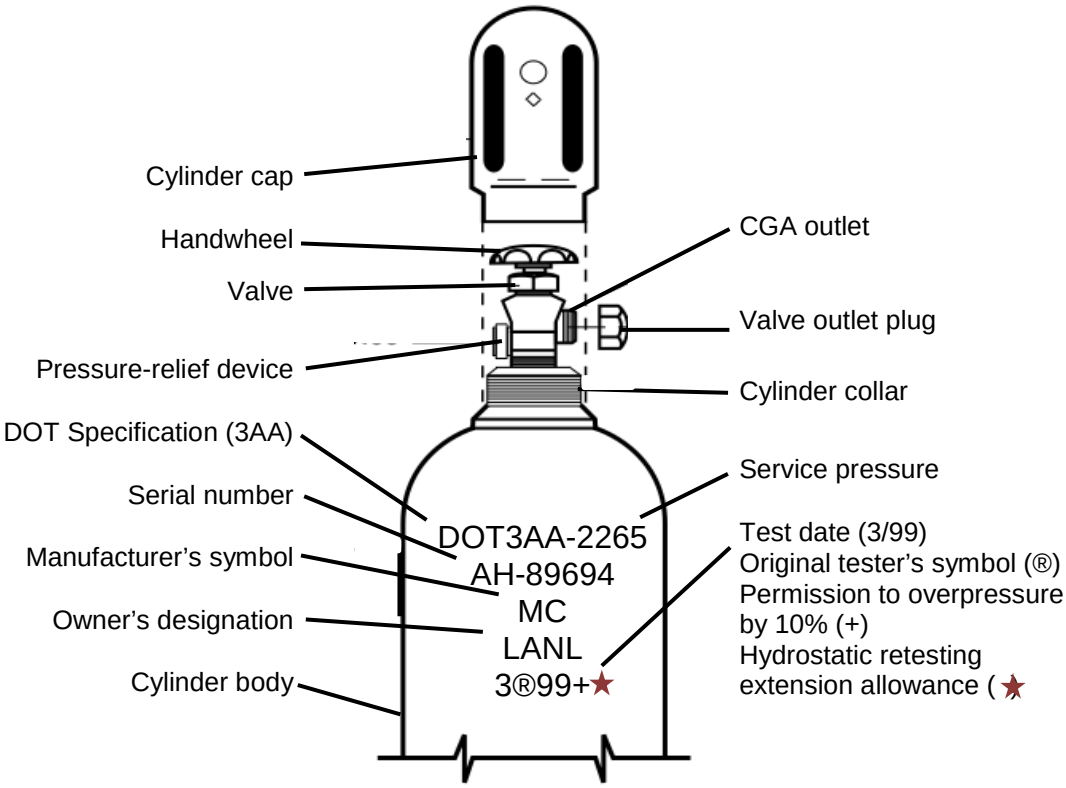
Cylinder markings are used to indicate the specifications of a cylinder, as indicated on the following pages.

All cylinders must be marked with

- the DOT specification,
- the service pressure for which the cylinder is rated,
- the manufacturer's serial number,
- a designation that identifies the manufacturer,
- a symbol that identifies the cylinder's owner,
- the last date on which the cylinder was tested, and
- special marks to indicate the overpressure allowance and the retest extension period, if appropriate.

Placement of Cylinder Markings

Typical cylinder markings are usually found on the cylinder's shoulder. Markings are generally arranged as illustrated below.



Typical cylinder markings.

Typical Gas Cylinder Markings

On the cylinder illustrated on the previous page,

- the DOT specification is 3AA;
- the service pressure is 2265 psig at 70°F;
- the manufacturer's serial number is AH-89694;
- the manufacturer is MC;
- the owner's designation is LANL;
- the last test date was March 1999 (the cylinder must be rejected and returned immediately if received after March 31, 2009—10-year limit); and
- the maximum allowed cylinder pressure is 2590 psi.

Special Markings

Some cylinders, such as the one previously illustrated, are stamped with a star and/or a plus sign. The following table explains the meaning of these two symbols.

This symbol . . .	means that . . .
★	the required interval for hydrostatic testing can be extended from 5 years to 10 years.
+	the cylinder can be filled to a pressure 10% greater than the cylinder's specified pressure.

Note: *DOT specifications for gas cylinders are found in Title 49, Transportation, Code of Federal Regulations (CFR), Part 178, Subpart C. These specifications detail cylinder construction, material, and testing requirements.*

Exercise

For a cylinder with only the following markings, complete the sentences below:

DOT8AL-250
BD-8642
WELCO
LANL
8®96

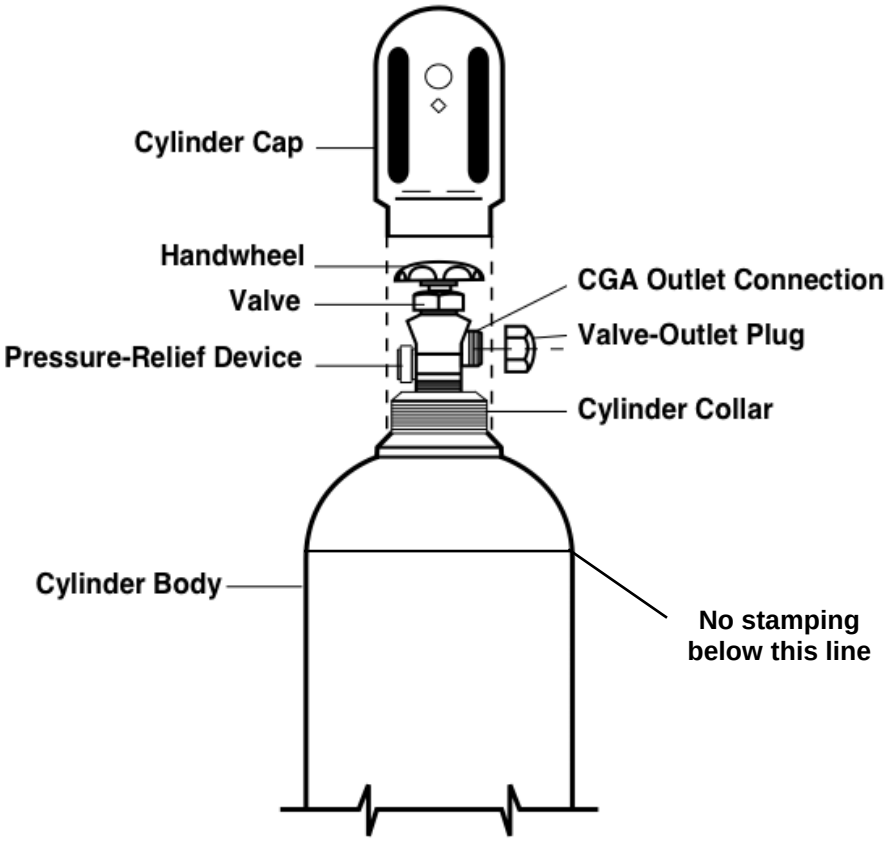
1. The DOT specification is _____.
2. The service pressure for this cylinder is _____ psig.
3. The manufacturer's serial number is _____.
4. The manufacturer is _____.
5. The owner's designation is _____.
6. The last test date was _____.
7. If this cylinder is received from a cylinder refilling company after August 31, 2006, it

   a. must be rejected.

   b. may be accepted.

Gas Cylinder Components

The components of a typical gas cylinder are shown below.



Gas cylinder components.

CGA outlet connection – the connection from the cylinder to the regulator.

Cylinder cap – a cap that screws onto the cylinder and protects the cylinder valve.

Cylinder valve – a valve used to release the pressurized contents of the cylinder to the system it services (see page 8).

Handwheel – the wheel used to open and close the cylinder valve. On some cylinders, a wrench is used in place of the handwheel.

Pressure relief device – a pressure- and/or temperature-activated device used to prevent the rupture of a gas cylinder (see page 8).

Valve outlet plug – a plug that screws into or onto the valve outlet to prevent foreign matter from entering the outlet port and to serve as a backup to a failed cylinder valve.

Carbon Dioxide Release

When employees at a laboratory attempted to use a 60-lb carbon dioxide gas cylinder, they found that they were unable to remove the cylinder cap by hand. They tried to loosen the cap by inserting a long screwdriver through the slats of the cap for leverage. In doing so, the main valve was opened and it began to release its contents, but the cap stayed in place. The lab personnel tried again, unsuccessfully, to loosen the cap, then left the area and notified Health and Safety support.

Lesson Learned

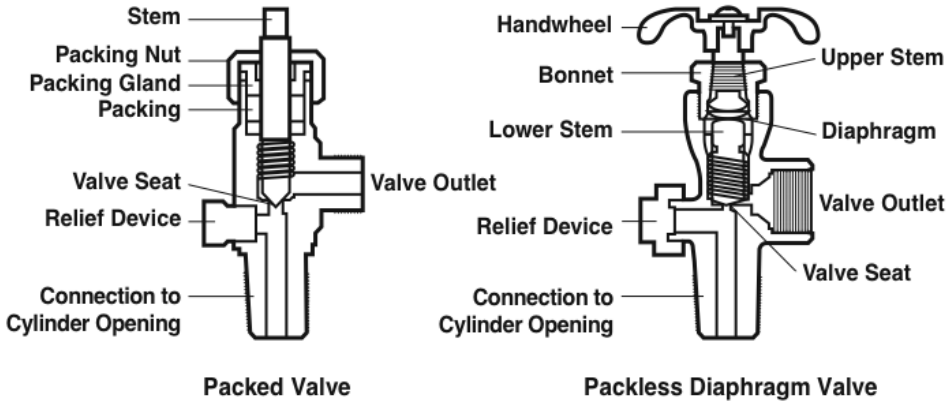
NEVER insert a tool into a cylinder cap in an attempt to open it. Try using a strap wrench, and if you still cannot remove the cap by hand, leave the cylinder as is and notify the gas plant.

~paraphrased from Laboratory Safety Incidents: Gas Cylinders, AIHA, June 2008

Cylinder Valves

A cylinder valve is used to release the pressurized contents of the cylinder to the system it services. The valve is the most fragile part of the cylinder. The cylinder cap protects the valve when the cylinder is not in use.

Valves and their subcomponents, including packing or diaphragms, are available in different materials that resist the corrosive properties of different gases. Diaphragms are used when ultrapure gas is required.



Cylinder valves.

Cylinder Pressure-Relief Devices

Most gas cylinders contain pressure-relief devices designed to prevent catastrophic cylinder failure. Pressure-relief devices are located in other parts of pressure systems for the same purpose.

The following table lists pressure-relief devices and their uses.

Pressure-Relief Devices and Their Uses	
Relief Device	**Uses**
Spring-loaded valve	• Vents enough gas to reduce pressure and then recloses. • Has broad applications. • Used for propane (including home use) and methylacetylene-propadiene (MAPP) gases.
Frangible-disc device	• Relieves pressure above a selected pressure. Used when overpressurization should result in discharge of the cylinder. • Used for carbon dioxide, oxygen, nitrogen, argon, and helium.
Fusible-plug device	• Relieves pressure above a selected temperature. • Effective in the event of fire or other source of cylinder heating. • Used for acetylene.
Disc/plug combination	• Used for hydrogen and methane. • Used when preset temperature and pressure must both be reached before relief occurs.
No relief device	• Used when release of extremely reactive or toxic gases, such as fluorine or arsine, would pose a more serious hazard. • Used when cylinder contents would corrode a rupture disc. ***Note:*** *Requires precautions, such as partial filling and pressurization well below the maximum allowable working pressure (MAWP), to prevent a release to the environment.*

Cylinder Connections to Regulators

Cylinders are connected to regulators by CGA fittings. To prevent the incorrect mixing or contamination of components, the CGA has specified sets of cylinder-valve outlets and regulator connections. In these specifications, gases are grouped by family (such as inerts and flammables), and only the gases within a particular family use the same connections. (See the CGA chart on the following pages.)

For example, oxygen passing through a regulator that contains even a small amount of oil from prior use with an oil-lubricated air compressor could cause the regulator to explode. This explosion in turn would vent oxygen from the source, possibly leading to further reactions. To prevent this and similar accidents,

- use only the regulators specified for the gas family you are handling, and
- never use an adapter between a cylinder and a regulator to defeat the CGA system.

***Note**: As an extra precaution against component mismatching, flammable-gas cylinders are designed almost without exception with left-hand threads.*

Color codes are not acceptable for identifying gas cylinder contents. Cylinders are often repainted, different vendors use different color codes, and colors can vary under different lighting conditions. To positively identify cylinder contents, read

- shoulder labels,
- valve and outlet tags, and
- stenciling.

Employee Injured in Pressurized Cylinder Explosion

An employee was reassembling a foam packing system. The employee incorrectly connected a new, fully charged (2600 psig) type T compressed nitrogen gas cylinder to a DOT type 4BW cylinder containing an isocyanate compound by means of an improperly modified regulator. The employee proceeded to pressurize the type 4BW cylinder with 2600 psig (from the nitrogen cylinder), which far exceeded that cylinder's safe working pressure of 240 psig and its approximate bursting pressure of 980 psig. Lacking adequate pressure relief devices, the overpressurized 4BW cylinder exploded, ejecting the isocyanate compound with great force. The employee sustained isocyanate chemical contamination and multiple serious injuries involving his eyes, ears, skin, and musculoskeletal system and was hospitalized.

~paraphrased from OSHA Accident Investigation Search 201061066

CGA Cylinder Connection Listing			
Gas	**Valve Outlet and Connection Number**	**Gas**	**Valve Outlet and Connection Number**
Acetylene	510 LH, 520 RH	Dichlorosilane	678/636
Air, breathing	346	Dimethylamine	705‡
Air, industrial	590*	Dimethyl ether	510*
Allene	510†	2-2 Dimethylpropane	510
Ammonia, anhydrous	705‡	Ethane	350*
Ammonia, electronic	660/720	Ethyl chloride	300*
Argon	580*/718	Ethylene	350*
Argon-3500 psig	680§	Ethylene oxide	510‡
Argon-6000 psig	677	Fluorine	679
Arsine	350/632	Germane	350/632
Boron trichloride	660‡/634	Halocarbon 12 (chlorotrifluoromethane)	660*/716
Boron trifluoride	330‡/642	Halocarbon 13 (chlorotrifluoromethane)	660/716
1-3 Butadiene	510*	Halocarbon 13B1 (bromotrifluoromethane)	660
Butane	510*	Halocarbon 14 (tetrafluoromethane)	320*/716
Butenes	510*	Halocarbon 22 (chlorodifluoromethane)	660*
Carbon dioxide	320*/716	Halocarbon 23 (fluoroform)	660/716
Carbon monoxide	350*/724	Halocarbon 114 (2,2 dichlorotetrafluoroethane)	660*
Carbon fluoride	660	Halocarbon 115 (chloropentafluoroethane)	660*
Carbonyl sulfide	330‡	Halocarbon 116 (hexafluoroethane)	660
Chlorine	660†	Halocarbon 142B (chloro 1,1-difluoromethane)	510
Cyanogen	660	Halocarbon 1113 (chlorotrifluoroethane)	510
Cyanogen chloride	660	Helium-3500 psig	680§
Cyclopropane	510	Helium	580*/718
Deuterium	350*	Hexafluoropropylene	660*

**Lecture bottles use CGA No. 170.*
†*Lecture bottles use CGA No. 110.*
‡*Lecture bottles use CGA No. 180*
§*For information on CGA 680 and 695 connections, contact your nearest Matheson office.*

CGA Cylinder Connection Listing (continued)			
Gas	**Valve Outlet and Connection Number**	**Gas**	**Valve Outlet and Connection Number**
Hydrogen	350*/724	Nitrogen-6000 psig	677
Hydrogen-3500 psig	695*	Nitrogen dioxide	660
Hydrogen bromide	330‡/634	Nitrogen trioxide	660
Hydrogen chloride	330†/634	Nitrous oxide	326*
Hydrogen fluoride	660‡/634	Octofluorocyclobutane	660*
Hydrogen iodine	330‡	Oxygen	540*/714
Hydrogen selenide	350	Oxygen mixtures over 23%	296
Hydrogen sulfide	330†/722	Perfluoropropane	660*/716
Isobutane	510*	Phosgene	660
Isobutylene	510*	Phosphine	350/632
Krypton	580/718	Phospherous pentafluoride	660‡
“Manufactured gas b”	350	Propane	510*
Methane	350*	Propylene	510*
Methyl bromide	330	Silane (high pressure)	350/632
3-Methyl butene-1	510	Silicon tetrafluoride	330‡/642
Methyl chloride	660*	Sulfur dioxide	660†
Methyl fluoride	350	Sulfur hexafluoride	590*/716
Methyl mercaptan	330†	Sulfur tetrafluoride	330‡
Monomethylene	705‡	Trimethylamine	705‡
Neon	580*/718	Vinyl bromide	510
Nitric oxide	660/712	Vinyl methyl ether	510
Nitrogen	580*/718	Xenon	580†/718
Nitrogen-3500 psig	680§		

**Lecture bottles use CGA No. 170.*
†Lecture bottles use CGA No. 110.
‡Lecture bottles use CGA No. 180.
§For information on CGA 680 and 695 connections, contact your nearest Matheson office.

Module 2: Gas Cylinder Hazards

Module Overview

Because of the high pressures and often dangerous materials they contain, gas cylinders pose serious hazards to those working with them. If you know the hazards associated with gas cylinders and their contents, you can take specific steps to protect yourself and those around you.

Module Objectives

When you have completed this module, you will be able to recognize

- general hazards associated with gas cylinders, including pressure and oxygen-deficiency;
- hazards resulting from the size and weight of some gas cylinders; and
- hazards associated with the contents of gas cylinders.

General Hazards of Gas Cylinders

Pressure

Gas cylinders are generally filled to pressures far below their capacity—often to 2100 psig (service pressure), although the cylinder MAWP is approximately 3000 psig. Many hazards arise from the sudden depressurization of such a highly pressurized object.

- A gas cylinder may become a projectile if its valve is broken off. Such cylinder projectiles have been known to crash through brick walls and roofs, causing serious injuries and damage to facilities.
- Overpressurization without a properly functioning pressure relief device can lead to a cylinder exploding, with flying shrapnel that can cause serious damage to personnel and property.

Oxygen Displacement

The normal oxygen concentration is 20.9%. If compressed gas escapes from the cylinder into the workplace, oxygen in the air may be displaced and reduced to dangerous levels. Oxygen displacement is especially hazardous in small, poorly ventilated areas. In areas in which the oxygen concentration falls below 16%, you can begin to lose consciousness before you realize that a problem even exists. Where oxygen displacement is a concern, the use of air monitoring and oxygen concentration alarms should be considered; this equipment should be set to alarm at 19.5%.

When released into poorly ventilated areas, dense gases will sink to the floor and into depressions, whereas light gases may accumulate near the ceiling. In either case, oxygen can be displaced to dangerously low levels.

Size and Weight Hazards of Gas Cylinders

Although gas cylinder lecture bottles are tiny and light, typical gas cylinders weigh from 115 up to 170 pounds. Improper handling of such cylinders can lead to

- a cylinder falling into expensive equipment;
- a cylinder falling into another cylinder;
- crushing injuries to the body, especially the fingers or feet; or
- sprains or strains when attempting to maneuver a cylinder.

Note: *Wear steel toed-shoes and use a hand cart when moving large gas cylinders. NEVER roll two cylinders at a time unless trained and authorized to do so.*

Gas Cylinder Accident during Loading

In 1992, a worker at a DOE vitrification facility system plant in New York state was chaining up an argon bottle in an approved loading area when *the cylinder tipped forward and struck him on the right hip*. He worked for the remainder of that day (Wednesday), Thursday, and Friday. He returned to work on Monday and reported to an occupational medicine nurse at the site, complaining of severe pain on the right side of his back. Upon examining him, the nurse found two large bruises on his right side.

An investigation revealed that the platform where the bottles were stored had an uneven surface. The top of two chains used to secure the cylinders was loose; when the worker tightened the bottom chain, the cylinder pitched forward and fell on his hip. The investigation results also suggested that the worker's lack of attention contributed to the occurrence.

Hazardous Materials within Gas Cylinders

All compressed gases can rapidly depressurize and displace oxygen. Some compressed gases have additional hazards, based on the contents of the cylinder. Families of compressed gases with additional hazards include

- oxidizing gases,
- flammable gases,
- poison (toxic) gases,
- corrosive gases, and
- cryogenic materials (in Dewars).

For information on the hazards associated with specific gases, refer to material safety data sheets (SDSs) or speak with an industrial hygienist.

Oxidizing Gases

Oxidizing gases are those gases that, in the presence of an ignition and a fuel source, promote the rapid combustion of flammable gases or materials. When oxidizing gases are released in certain concentrations, an explosion could result. Examples of oxidizing gases include oxygen and nitrogen dioxide.

Flammable gases and oxidizers will react violently when mixed and ignited. For many mixtures of these two families of gases, even a small amount of heat from friction can result in ignition.

Note: *Always store oxygen cylinders at least 20 feet from flammable gas cylinders or separate them with a 5-foot-high, half-hour firewall. Keep oxygen containers, valves, regulators, hoses, and other cylinder parts free from oil or grease, and do not handle them with oily hands, oily gloves, or greasy equipment.*

Flammable Gases

Flammable gases are easily ignited and are capable of burning rapidly. The following table lists some flammable gases, their DOT designation, and their UN identification number. The DOT Hazard Class/Division for flammable gases is 2.1, referring to “compressed gas” (Class 2) and “flammable hazard” (Division 1). The UN number is a four-digit number representing a particular chemical or group of chemicals.

Flammable Gases Proper Shipping Name	Class/Division	UN Number
Acetylene, dissolved	2.1	UN1001
Carbon monoxide	2.3*	UN1016
Deuterium, compressed	2.1	UN1957
Ethane	2.1	UN1035
Hydrogen, compressed	2.1	UN1049
Isobutane	2.1	UN1969
Methane, compressed	2.1	UN1971
Propane	2.1	UN1978

* *Although carbon monoxide is flammable, the DOT considers the greater hazard to be poison, so the division is 2.3.*

Note: *Flammable-material storage areas must be posted with NO SMOKING signs. Fire extinguishers or fire suppression systems may be required.*

Acetylene and hydrogen are two flammable gases that are commonly used at LANL. Some of the unique hazards of these gases are as follows:

- Acetylene is stored in acetone. Failure to keep acetylene cylinders in an upright position can allow the acetone to leak into the valve.
- Hydrogen can cause embrittlement in certain metals, potentially resulting in a loss of ductility and/or diminished impact strength.

Poisonous Gases

Exposure to poison (toxic) gases may cause acute injury or death to workers, the public, and the environment. The DOT Hazard Class/Division for poison gases is 2.3, referring to compressed gas (Class 2) and the "poison-inhalation hazard" (Division 3). The following table lists some poisonous gases, their DOT designation, and their UN identification numbers. Letters in the hazard zone column indicate hazard levels (where A is the most toxic and D is the least toxic). Immediately dangerous to life and health (IDLH) concentrations should be reviewed when developing health and safety controls.

Poison Gases Proper Shipping Name	IDLH* (ppm)	Class/ Division	UN Number	Hazard Zone
Carbon monoxide	1200	2.3	UN1016	D
Chlorine	10	2.3	UN1017	B
Fluorine, compressed	25	2.3	UN1045	A
Hydrogen Sulfide	100	2.3	UN1053	B
Phosgene	2	2.3	UN1076	A
Sulfur dioxide	100	2.3	UN1079	C

**Source: NIOSH Pocket Guide to Chemical Hazards, August 2006.*

Corrosive Gases

Corrosive gases may degrade materials and cause damage to bodily tissues on contact. The following table lists examples of corrosive gases that are stored in pressurized cylinders. Note that the DOT does not consider corrosivity to be the primary hazard.

Corrosive Gases Proper Shipping Name	Class/ Division	UN Number	Hazard Zone
Ammonia	2.3(8)	UN1005	D
Hydrogen chloride, anhydrous	2.3(8)	UN1050	C
Trifluoroacetylchloride	2.3(8)	UN3057	D
Tungsten hexafluoride	2.3(8)	UN2196	D

* *Although these gases are corrosive, the DOT considers the greater hazard to be poison, so the Class/Division is 2.3(8).*

Note: *Return cylinders containing corrosive gases within 1 year because the cylinder containing the corrosive gas might withstand the corrosive effects for only a limited period of time.*

Cryogenic Materials

Cryogen materials are stored in cryogen containers that are pressurized, cylindrical in shape, and require many of the same safe-handling procedures that apply to gas cylinders. However, Dewars containers are not pressurized, are open to the atmosphere, and are used for shorter-term storage and delivery.

Cryogenic materials are extremely cold and may cause cold burns if not stored, moved, and handled with care. Cryogen vaporization, having an expansion factor close to 1000 at an altitude of 7000 feet, displaces a significant amount of breathable air.

The following table lists some cryogenic materials and their DOT designation and UN identification numbers.

Cryogenic Materials Proper Shipping Name	Class/ Division	UN Number
Argon, refrigerated liquid	2.2	UN1951
Helium, refrigerated liquid	2.2	UN1963
Hydrogen, refrigerated liquid	2.1	UN1966
Nitrogen, refrigerated liquid, cryogenic liquid	2.2	UN1977
Nitrogen, compressed	2.2	UN1066
Oxygen, refrigerated liquid	2.2	UN1073

Module 3: Gas Cylinder Control Measures

Module Overview

To work safely with gas cylinders, you must understand and follow appropriate hazard-control measures related to cylinder handling, storage, transport, and procurement. You must also know how to respond to an accidental or uncontrolled release of cylinder contents.

Module Objectives

When you have completed this module, you will be able to

- recognize engineering and safe work practices for gas cylinder storage, handling, and use;
- recognize controls for gas cylinder content hazards;
- recognize PPE for gas cylinder handling and use;
- recognize safe work practices and labeling and placarding requirements for gas cylinder transport;
- recognize the process for the procurement, delivery, and return of gas cylinders at LANL;
- recognize the steps to take in the event of an accidental or uncontrolled gas release from a cylinder; and
- identify resources for gas cylinder information and assistance.

Engineering Controls

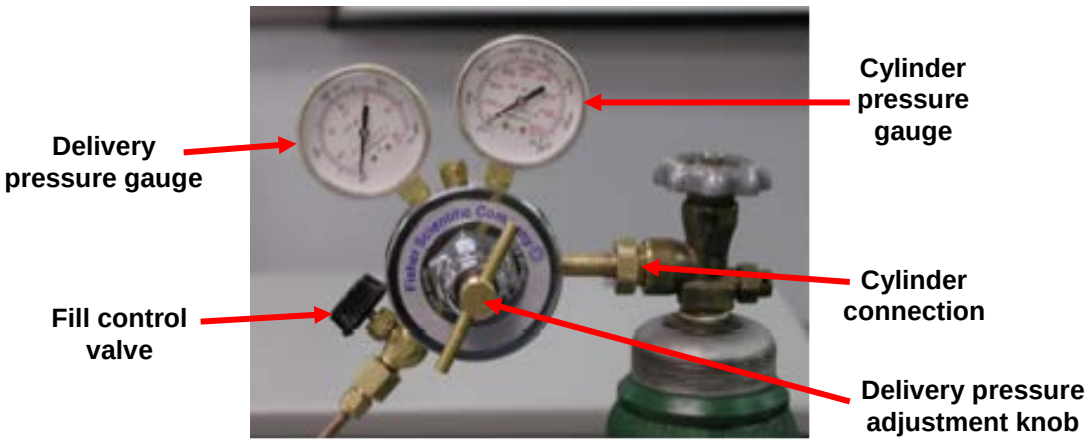
General types of engineering controls for the storage and use of compressed gas cylinders include the following.

Ventilation – To prevent oxygen displacement and exposure to cylinder contents, compressed gas cylinders should be used and stored in well-ventilated areas. When local exhaust ventilation such as a fume hood is used, a scrubber may be needed to treat or remove captured gases before exhausting them from the building.

Enclosure – An enclosure such as a gas cabinet can provide ventilation, security, and/or fire suppression (depending on the type of cabinet).

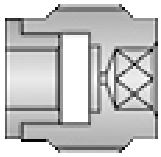
Air monitoring – If a work area could become oxygen deficient as a result of compressed gas release or if low levels of the gas(es) being used could cause adverse reactive or health effects, the air may need to be monitored. Air-monitoring equipment may be handheld or wall mounted. The equipment may be gas specific, or it may measure a characteristic, such as the lower explosive limit of flammable gases. Monitoring devices can also be connected to building or area alarms that indicate oxygen deficiency, inadequate ventilation, etc. Contact your health and safety professional for assistance with the selection and use of air-monitoring equipment.

Pressure regulator – A pressure regulator is a mechanical device used to safely control the discharge pressure of a compressed gas from a container. A variety of pressure regulators are used with compressed gas cylinders, including single-stage, two-stage, low-pressure, and high-pressure regulators.



Functional Test of Regulator

1. Close the regulator by turning the pressure-adjusting valve *counterclockwise* until the key is fully released.
2. Close the cylinder valve, and drain the downstream line.
3. The low-pressure gauge will indicate zero. Record the low-pressure gauge reading. The high-pressure gauge will read full pressure. Record the initial high pressure.
4. If the low-pressure gauge does not read zero when all pressure is removed, it may be damaged and must be replaced.
5. Check the high-pressure gauge reading after at least 30 minutes. Record the high-pressure reading. Any pressure drop will indicate leakage.
6. Release the pressure in the regulator by turning the pressure-adjusting key clockwise. After venting, fully release the pressure-adjusting key by turning it counterclockwise.



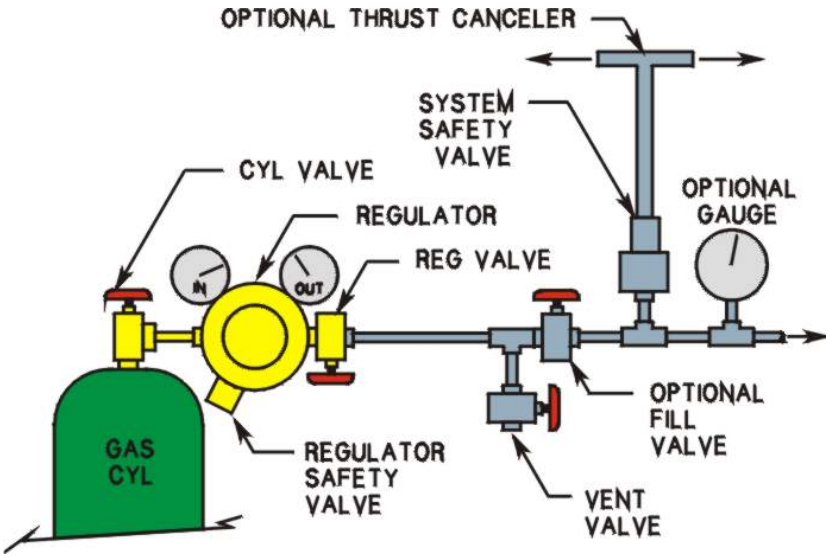
An RFO limits the flow of gas from a gas cylinder.

Restrictive flow orifice – A restrictive flow orifice (RFO) is a device that limits the flow of gas from a cylinder. An RFO can be used to ensure that gas that is leaking from a cylinder escapes at a low rate. When used with local exhaust ventilation such as a fume hood, the RFO can reduce the risk that escaping gas will overwhelm the exhaust system and enter the workplace.

Safety manifold – In dead-ended systems, fluids (including gases) are held under continuous pressure. At LANL, many dead-ended pressure systems are supplied by compressed gas. All dead-ended systems require a safety manifold to control the source gas from its entry point to its end use. Safety manifolds

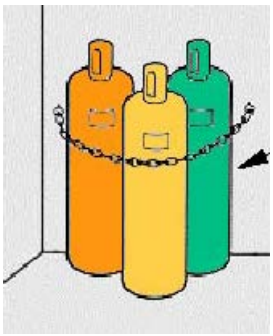
An acetylene torch is an example of an open-ended system in which pressurized gases flow directly into the open atmosphere.

- regulate delivery pressure,
- protect from overpressurization,
- indicate pressure level,
- vent unused pressurized gas, and
- –are supplemented by end-use pressure gauges.

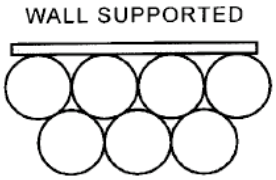


Basic components of a safety manifold system.

Safe Work Practices for Gas Cylinders



If using a wall for support, ensure that all cylinders are in contact on three points, either with the wall or with other cylinders.



By following safe practices when working with gas cylinders, you will minimize your risk of accidents. Safe work practices apply to the storage, handling, and use of compressed gas cylinders.

Gas Cylinder Storage

- Store cylinders in well-ventilated areas, away from temperature extremes, moisture, corrosives, and objects that may strike or fall on them.
- Avoid storing cylinders at temperatures above 125°F. Never allow a flame or welding arc to contact any part of a cylinder. If ice or snow accumulates on a cylinder, before using it, thaw it at room temperature or with water no hotter than 125°F.
- Avoid low temperatures. Cylinders must not be subjected to cryogenically low temperatures without approval from the supplier. The toughness and ductility (ability to sustain an impact and be deformed by elongation without fracture) of many types of steel are decreased at low temperatures.
- Secure cylinders upright during storage and use. Use cylinder racks if possible. When storing multiple cylinders without racks, position the cylinders so that they are in contact on three points, either with other cylinders or with the wall, and then secure them. Never leave a standing cylinder unsecured.
- Keep cylinder caps in place, except when the cylinders are connected to dispensing equipment.
- Keep valve-outlet plugs in place, except when the cylinders are connected to dispensing equipment.
- Keep valves closed when cylinders are “empty” or not in use.
- Do not store cylinders of acetylene on welding carts—welding carts are designed for use, not storage.

A variety of storage options ensures that cylinders remain upright and secure.

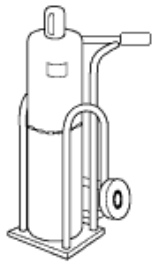
Gas Cylinder Storage Deficiencies Identified

A review of areas used to store compressed gas cylinders in a DOE facility revealed a failure to follow site requirements for gas cylinder storage. Specific deficiencies included the following.

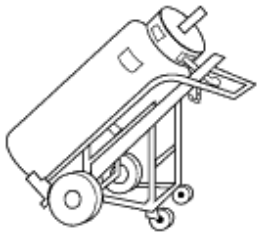
- Cylinder storage areas were posted for one type of cylinder but contained other types.
- Cylinder bottle labels were missing or damaged, or the cylinders were incorrectly labeled.
- Cylinders were observed with missing valve protection caps.
- Cylinders were chained in large masses and were not properly secured in accordance with site standards.
- Empty and full cylinders were not segregated.
- Oxidizers were found stored too closely to fuel gases.
- There was evidence of cigarette smoking near flammable compressed gas storage areas.

~paraphrased from Lesson ID: Y-1996-OR-LMESY12-0402

Gas Cylinder Handling and Use



For extended distances, move cylinders on



- Be aware of adjacent operations. (See the Lessons Learned on page 25 for an example of conflicting adjacent operations).
- Use an approved handcart to move a cylinder for extended distances, and secure the cylinder with straps or chains. Always inspect the handcart before you use it. Do not roll cylinders on their sides, do not drag cylinders, and do not roll two cylinders at a time unless you are trained and authorized to do so.
- Never lift cylinders by their caps.

Compressed Gas Cylinder Cart Collapsed during Use

A gas cylinder cart capable of being used as a two- or four-wheel cart had a locking mechanism that malfunctioned, causing the cylinder cart to collapse and the cylinder to hit the ground. The employee had not inspected the cart before use and so did not notice that the locking mechanism knob had become partially unscrewed. Although the cylinder was capped and chained to the cart, the chain holding the cylinder to the cart was not tight enough to prevent the cylinder from slipping off the cart. The poor design of the cart, as well as the failure to inspect the cart before use for possible defects, led to the mishap.

~paraphrased from Lesson ID: 2008-NBL-0001

- Use only components that are compatible with cylinder contents, and never modify components.
- Open cylinder valves slowly. Never excessively force valves open.

- Check for leaking cylinders. Consider the following methods of leak detection.
  - Use portable gas leak detectors, which haveexcellent limits of detection.
  - Use a soapy-water solution or a 50% glycerin/water solution to detect bubbles.
  - For a flammable gas, use a flammable gas detector.
  - For systems where toxic or corrosive gases will be used, first test the system with an inert gas before introduction of the hazardous material.

  In the event of a leaking cylinder, follow your site procedures. If the leak is in the valve packing or stem, contact the LANL Compressed and Liquefied Gas Facility (or “gas plant”).
- Avoid prolonged, rapid depressurization of a gas cylinder. During rapid depressurization, the exhausting gases may cool the vent nozzle to temperatures where the loss of ductility may produce brittle failure of the metal wall while at the same time creating severe stress levels.
- Vent gases away from building-ventilation air intakes.

Employee Loses Control while Rolling Two Cylinders at a Time

A technician and two graduate students were nearly hit by a 115-pound nitrogen gas cylinder. During delivery at a building delivery dock, a gas plant worker was rolling two cylinders, in accordance with industry standard practices, from the bed of the delivery truck onto a Tommy lift. One cylinder rolled over a depression on the smooth metal transition plate between the bed and Tommy lift and began to slip toward the end of the Tommy lift. The cylinder fell 4 feet, landed on its base, and then fell on its side, narrowly missing a technician and two graduate students, who were bringing excess chemicals into the building as part of a housekeeping project. The project had been planned and included in the facility plan of the week.

The following factors contributed to this incident:

- Damaged surfaces existed in the bed, bed lip, and skid plate of the delivery truck.
- The skid plate had a smooth rather than nonskid surface. Movement of gas cylinders from the bed of the truck requires rolling them by hand because of space limitations, and flat surfaces are critical to facilitate rolling the cylinders safely.
- Neither the gas plant workers nor the technician/graduate students from the facility analyzed the hazards associated with using the dock/delivery area for competing tasks. Each group focused on their individual task without taking into consideration other activities associated with a busy dock/delivery area.
- The gas plant workers had been successful on multiple occasions manipulating two gas cylinders at a time in truck beds. Moving two gas cylinders at a time is considered a skill of the craft and, although the practice is discouraged by LANL's gas cylinder safety training, it is not prohibited. Gas plant workers consider manipulating two gas cylinders at a time to be an acceptable industry practice, and this practice was verified by management. The gas plant workers involved in this event were experienced and routinely manipulated two gas cylinders without mishap.
- The delivery dock was located such that the gas delivery truck had to be backed into the delivery area, which elevated the back of the truck above the front of the truck. As a result, cylinders had to be moved up a slight incline to the Tommy lift. According to the gas plant workers, this configuration made it a little more difficult to maintain control of the cylinders.

~paraphrased from NA-LASO-LANL-MATWAREHS-2006-0007

Controls for Cylinder Gas Content Hazards*

General controls for gas cylinders with hazardous contents include the following:

- Know the locations of
  - operational eyewash stations and emergency showers,
  - material SDSs, and
  - fire extinguishers and exits.
- Flammable gases and oxidizers will react violently when mixed and ignited. Controls used to separate oxidizers and flammables include
  - a 20-foot separation or a 1/2-hour, 5-foot-high firewall for storage areas;
  - check valves to prevent the mixing of reactive gases; and
  - regulators and fittings appropriate for each family of gases.

Drywall that is 5/8 inches thick meets the half-hour separation requirement.

- Keep oxygen containers, valves, regulators, hoses, and other cylinder parts free from oil or grease, and do not handle them with oily hands, oily gloves, or greasy equipment.
- Post flammable-gas cylinder storage areas with NO SMOKING signs.
- For acetylene gas cylinders,
  - leave the acetylene cylinder valve key or wrench on the cylinder valve during use to allow rapid closure in case of emergency and
  - open an acetylene cylinder valve no more than one full turn to allow for rapid closure in case of emergency.
- For poison (toxic) gas cylinders,
  - use less-toxic substitutes whenever possible and
  - order the smallest quantity needed.
- Locate poison, corrosive, and reactive gas cylinders in an exhausted enclosure with an appropriately sized RFO.

* *Not all types of cylinder gas hazards are addressed here, and not all types of cylinder gas controls are presented here.*

Personal Protective Equipment (PPE)

When wearing PPE for any hazard, you must know the following:

- when the PPE is necessary;
- what PPE is necessary;
- how to properly don, doff, adjust, and wear the PPE;
- the limitations of the PPE; and
- the proper care, maintenance, useful life, and disposal of the PPE.

Compressed-gas systems can fail. If failure occurs, pressurized gas may be released and system components may shatter. Always wear safety glasses when working around gas cylinders.

Gas cylinders are heavy enough to injure feet and toes severely. Wear appropriate foot protection when moving cylinders.

Gas cylinder contents and/or tasks requiring the use of gas cylinders may pose hazards that require additional PPE, such as gloves, protective clothing, or respiratory protection. Examples include welding and the use of cylinders containing poisonous, corrosive, or reactive gases.

Note: *To wear any type of respiratory protective equipment at LANL, you must meet the training and qualification requirements of the Respiratory Protection Program.*

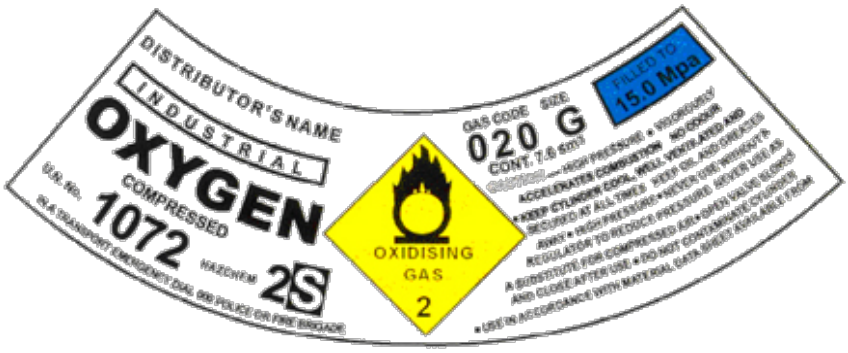
Gas Cylinder Transport

Transporting gas cylinders requires specific precautions to protect workers and the public. When you are transporting gas cylinders in vehicles, follow these safety practices.

- Keep cylinder caps and valve-outlet plugs (if available) in place, and NEVER transport a cylinder with a regulator attached.
- Secure gas cylinders upright in racks or restraints.
- Transport cylinders in open trucks only. Never transport cylinders inside truck cabs or automobiles.

Labels and Placards

Cylinder labels and DOT vehicle placards help to communicate the hazards associated with the cylinders being transported.



Placards are placed on vehicles to indicate the primary nature of the hazardous material(s) being transported. Secondary hazards, which also may be present, are not communicated by placards.

Placards must be placed on gas-cylinder transport vehicles if the gross weight of the cylinders and their contents exceeds 1000 pounds. Placards also are required for any quantity of Class/Division 2.3 poison gas. When placards are required, they must be placed in clearly visible locations on the front, back, and both sides of the transport vehicle. Placards readily communicate the hazards that the shipment poses to workers and the public.

Hazardous-material shipments must be accompanied by a hazardous material transfer form (HMTF) or a radioactive material transfer form (RMTF). For more information, contact the Packaging and Transportation Group (the gas plant) at 7-4406.

Procurement, Delivery, and Return of Gas Cylinders

Cylinder Procurement

At LANL, before you may order compressed gases in cylinders, you must have authorization from your supervisor. For assistance in the authorization process, contact the Packaging and Transportation group at 7-4406.

The gas plant personnel assist with all gas cylinder deliveries and returns, including direct pickups by non-gas-plant personnel. Workers at the gas plant

- refill gas cylinders,
- supply larger volumes of gases in tube trailers,
- deliver specialty gases from vendors,
- deliver gas cylinders to your facility, and
- pick up empty cylinders.

Cylinder Delivery and Return

Gas plant personnel have established the following cylinder-handling practices and requirements:

- The cylinder delivery area at your facility should be clean, free of snow, accessible, and located outside.
- Cylinders picked up directly from the gas plant will be loaded only onto open government vehicles with racks or restraints.

- Empty cylinders should contain at least 25 psig of pressure to prevent contamination.
- Cylinders for return should be disconnected, standing, and secured, with their caps in place.
- Cylinders for return should be tagged with standard “RETURN” tags.
- Special notations (such as “partially full, ~400 psi”) should be indicated on the tags, not on the cylinder itself.
- Tags should not be attached to the cylinders with tape.
- Cylinders containing poisonous and flammable gases should have their valve-outlet plugs in place.
- Cylinders used at facilities with radioactive contamination must be monitored and have a Health Physics Release tag.

Accidental or Uncontrolled Releases

If an accidental or uncontrolled release of gas cylinder contents occurs, you may have only seconds to respond. Unless your site-specific procedures indicate differently, take the following steps:

1. Evacuate the area. Release of
   – inert gases displaces breathable air and can result in unconsciousness;
   – poisonous gases can be immediately dangerous to life or health (IDLH); and
   – release of flammable gas can result in a fire or explosion.
2. Call 911, and stay on the line to provide the dispatcher with information that may requested.
3. Notify your supervisor.
4. Monitor (or have someone monitor) the air in the workplace before reentering to ensure that the area has been sufficiently ventilated. Flammable or toxic gas concentrations must be reduced to acceptable levels; oxygen concentration must be between 19.5% and 23.5%.

Gas Cylinder Resources

The following table lists contacts for information and assistance regarding gas cylinder safety and procedures.

For information or assistance on . . .	call . . .	at . . .
gas cylinder packaging and transportation	Packaging and Transportation (the Gas Plant)	7-4406.
the design, installation, inspection, and safe use of pressurized systems	Industrial Hygiene and Safety	6-0295.
online signature authorization	Lab-Wide Systems Support	7-9444.
orphaned cylinders	Emergency Management	7-6211.
training on pressure safety and related topics	Institutional Training Services	7-0059.

Additional Training

Additional training is provided by institutional environmental, safety, and health training services. Courses that may be relevant to your work are listed below.

- Chemical Hazard Communication Introduction (#25418 or self-study #25997)
- Compression Fittings (#30831)
- Cryogen Safety (#8876)
- Hazardous Materials Packaging and Transportation (HMPT) training (call the White Rock Training Center at 7-0059)
- Flammable Gas Safety Self-Study (#52827)
- Personal Protective Equipment Introduction Self-Study (#28886)
- Pressure Safety Advanced (#11549)
- Pressure Safety Orientation (#769)
- Welding Safety Self-Study (#9519)

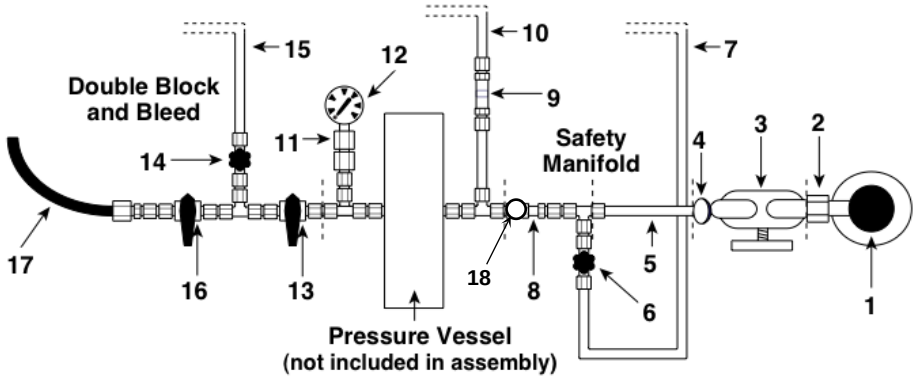
To register for a live course or to access a self-study, go to http://utrain.lanl.gov or call Institutional Training Services at 7-0059.

Hands-On Exercise: Pressure System Assembly

The diagram below shows a top-down (bird's eye) view of a typical pressure system. During this hands-on exercise, you will complete the system that was partially assembled in the *Pressure Safety Orientation* course.

The purpose of this exercise is to familiarize yourself with a safe procedure for connecting a regulator to a gas cylinder and for setting it to a specified pressure.

Note: *Safety glasses are required whenever a gas cylinder valve is opened and are highly recommended even if only the valve protection cap is removed.*



1 Cylinder
2 CGA connection
3 Regulator
4 Regulator fill valve
5 Down tube
6 Vent valve
7 Vent tube
8 Check valve
9 Pressure-relief device
10 Vent tube
11 Snubber
12 System gauge
13 Blocking valve
14 Vent tube
15 Vent tube
16 Blocking valve
17 Pigtail
18 Fill valve

Pressure system assembly.

Instructions: To complete the pressure system, follow these steps, referring to the figure above.

1. Check the gas cylinder on your bench for appropriate labeling and markings.
2. Put on safety glasses. **Note:** Everyone present must be wearing safety glasses before you proceed to step 6.
3. Clean the cylinder valve outlet with the machinist's cloth provided. It is best to have the cloth bunched up (your instructor will explain).
4. Connect the regulator (3) to the CGA connection (2) on the cylinder (1). Support the regulator while making the connection to eliminate any load on the threads. First, hand-tighten the connection such that the regulator is fairly snug with the cylinder; then wrench-tighten it with about 50 lbs of force on the end of the wrench. ***Note:*** *Overtightening could mar the sealing surface of either the CGA connection or the cylinder valve.*
5. Connect the regulator to the down tube (5) on the previously assembled pressure system. Hand-tighten and then wrench-tighten to no more than a half turn.
6. Check that all valves in the system are closed.
7. Stand off to the side, and open the cylinder valve a quarter turn to a half turn while observing the system gauges.
8. Test for leaks at the CGA connection (2). If a leak exists, close the cylinder valve and bleed the remaining pressure through the regulator (3), the regulator fill valve (4), and the first vent valve (6). Retighten the CGA connection and retest for leaks. If the leak continues, notify the instructor.
9. Set the regulator pressure to 13 psig. Notice that the pressure reading on the system gauge is lower than the reading on the regulator gauge. This reading is lower because a check valve has been installed.
10. Optional: Continue leak-testing the system by opening the regulator fill valve (4) and the first blocking valve (13). Keep the other valves (6, 14, and 16) closed while leak-testing. Retighten connections and retest for leaks as needed.
11. Inflate the balloon provided.
12. Record the residual cylinder pressure on the tag provided.
13. Shut down the system by closing the cylinder valve and venting all system components.
14. After completing the exercise, leave the system with all valves closed, including the regulator valve.

Self-Assessment

1. Which of the following is a physical hazard associated with the high pressures inside all gas cylinders?
   a. spontaneous combustion
   b. flammability
   c. poison inhalation
   d. shrapnel
2. The purpose of CGA fittings is to
   a. provide a reliable point with which to lift a cylinder
   b. relieve pressure above a selected temperature
   c. provide ventilation, security, and/or fire suppression
   d. prevent the incorrect mixing or contamination of components
3. Each of the following is a type of pressure relief device used on a gas cylinder EXCEPT a
   a. fusible plug
   b. restrictive flow orifice
   c. spring-loaded valve
   d. frangible disc
4. Placards are required on vehicles transporting gas cylinders when the gross weight of the cylinders and their contents exceeds
   a. 1000 lb
   b. 1500 lb
   c. 2000 lb
   d. 5000 lb
5. A restrictive flow orifice (RFO) is a device that
   a. screws onto the cylinder and protects the cylinder valve
   b. limits the flow of gas from a cylinder
   c. is used to open and close the cylinder valve
   d. connects the cylinder to the regulator

6. Which of the following is a recommended gas cylinder storage practice?

   a. Ensure that regulators are attached securely to the cylinders

   b. Store cylinders in freezing temperatures to reduce metal fatigue

   c. Keep cylinder caps in place, except when the cylinders are connected to dispensing equipment

   d. Store flammables with oxidizers to reduce cylinder handling

7. Cylinders in transport should

   a. have a restrictive flow orifice with a spring-loaded valve

   b. be secured upright in racks or restraints

   c. have regulators attached to prevent cross-contamination

   d. be placed on their sides and parallel with the vehicle

8. All of the following apply to the delivery and return of gas cylinders at LANL EXCEPT for

   a. cylinders containing poisonous and flammable gases, which should have their valve-outlet plugs in place

   b. cylinders for return, which should be disconnected, standing, and secured, with their caps in place

   c. cylinders for return, which should be completely empty and tagged with standard return tags

   d. cylinder delivery to your facility, which should be to a clean, snow-free, accessible, outside dock

9. In the event of an emergency involving damaged or leaking gas cylinders, you should

   a. make every effort to stop the leak

   b. call your supervisor

   c. call the gas plant

   d. evacuate the scene and call 911

Answers

Answers to Exercise (page 6)

1. The DOT specification is 8AL.
2. The service pressure for this cylinder is 250 psig.
3. The manufacturer's serial number is BD8642.
4. The manufacturer is WELCO.
5. The owner's designation is LANL.
6. The last test date was August 1996.
7. If this cylinder is received from a cylinder refilling company after August 31, 2006, it must be rejected (because the last test date does not include a "★" symbol).

Answers to Self-Assessment Questions (page 33)

1. d
2. d
3. b
4. a
5. b
6. c
7. b
8. c
9. d

Notes . . .

References

ANSI Z49.1, *Standard on Safety in Welding and Cutting* (American National Standards Institute, New York).

29 CFR 1910.101, [Code of Federal Regulations] *Compressed Gases* (US Department of Labor, Washington, DC).

29 CFR 1910.1200, [Code of Federal Regulations] *Hazard Communication* (US Department of Labor, Washington, DC).

49 CFR, 106–180, [Code of Federal Regulations] *Transportation* (US Department of Transportation, Washington, DC).

CGA V-1, *American National, Canadian, and Compressed Gas Association Standard Compressed Gas Cylinder Valve Outlet and Inlet Connections* (Compressed Gas Association, Inc., Arlington, VA).

CGA P-14, *Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres* (Compressed Gas Association, Inc., Arlington, VA).

Handbook of Compressed Gases, Third Edition (Compressed Gas Association, Inc., Arlington, VA).

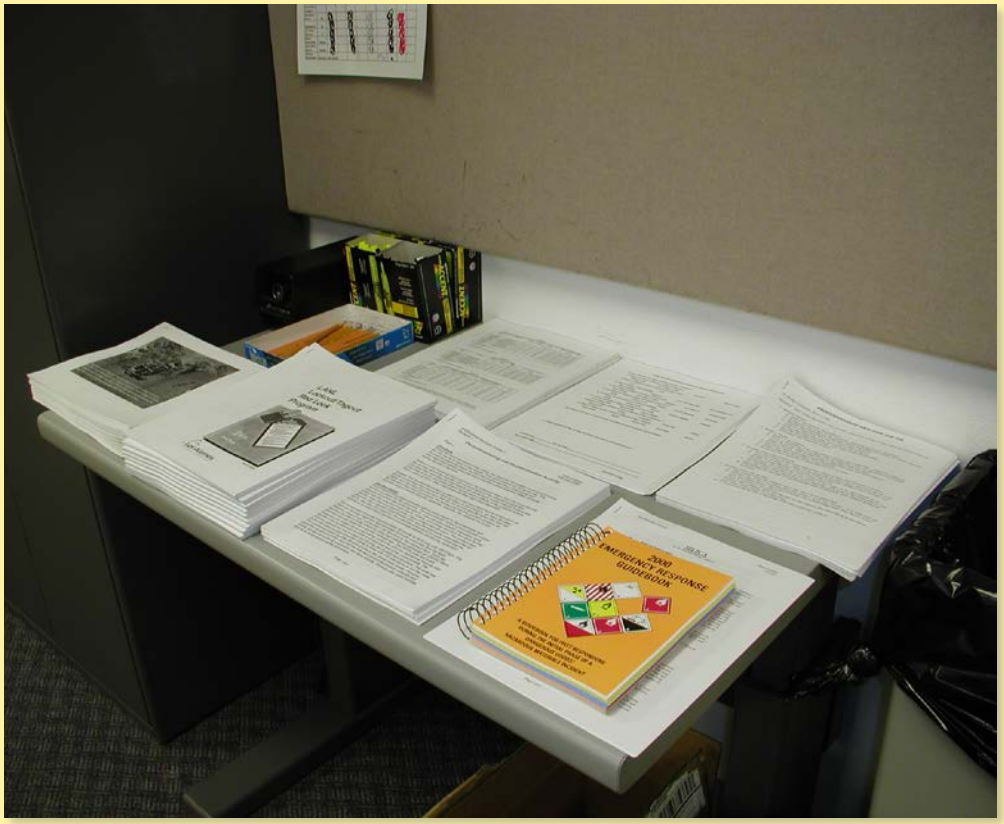
P101-34, *Pressure Safety* (Los Alamos National Laboratory, Los Alamos, NM).

Laboratory Safety Incidents: Gas Cylinders, American Industrial Hygiene Association, June 2008.

Welcome to the White Rock Training Center

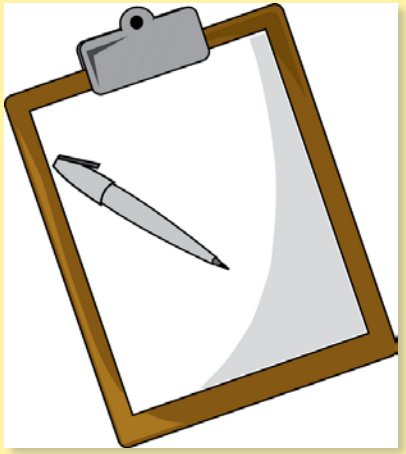
Before You Sit Down . . .

Pick up course materials when you enter the room.

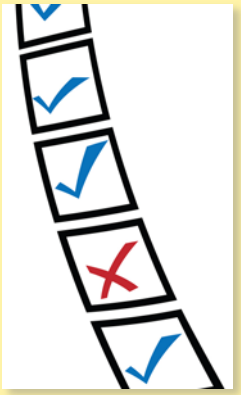


When in the Classroom . . .

- Be sure to sign the roster.
  - print your name legibly
  - sign your name
  - print your Z number

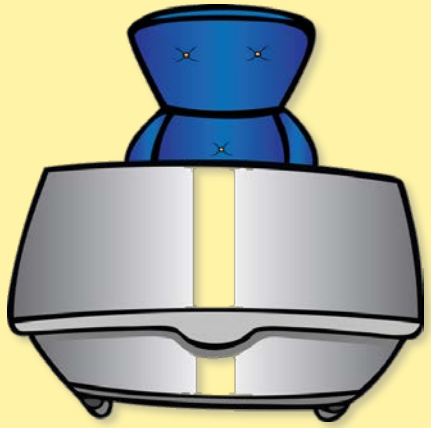


- Make sure to fill out a class evaluation. We value your feedback!



Please Be Courteous!

- So others can exit easily, always push in your chair when you take a break or leave the classroom.



- Turn off cell phones, or put them on vibrate.

Cell Phones

- Your cell phone texting or conversation may interfere with the learning process of other students.

- Please take your phone calls to the student lobby, and have your conversation there.

Thank you!

Yes, we're all very interested in what you're having for dinner tonight.

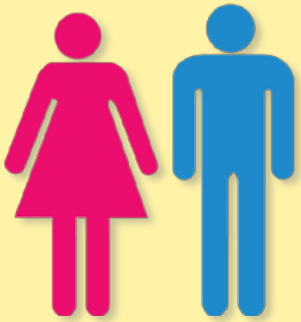
(Please keep phone conversations to yourself.)

Break Time

- Telephones are located in the front lobby, just beyond the reception area.

- Soft drink and snack machines are located by the telephones.

- Restrooms are located off the hallway between the reception area and classrooms 114–118.



Recycle Your Aluminum Cans & Plastic Bottles

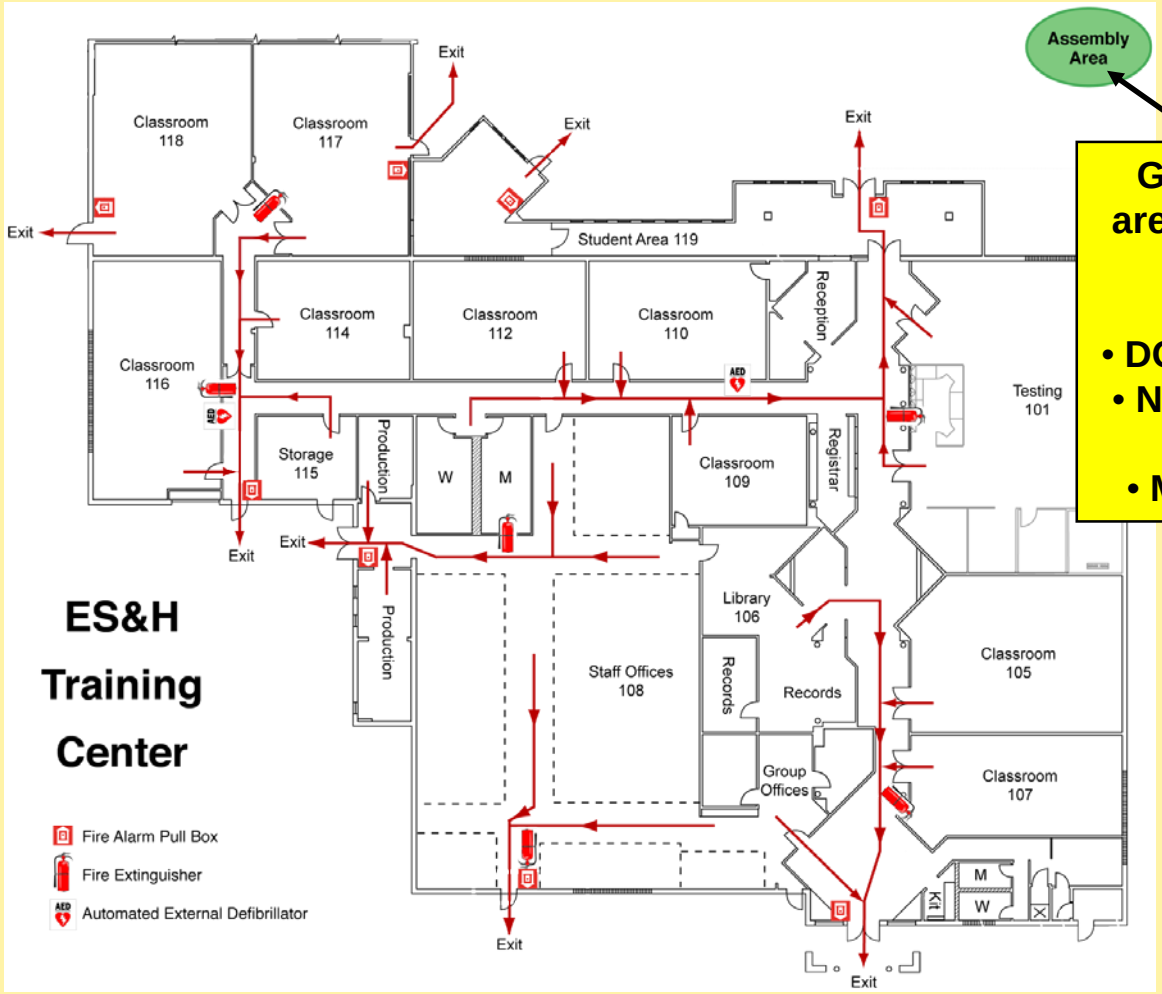
- **Please** put trash and recyclables in the proper receptacles located in the front lobby. Don't leave trash at your seat.

Emergency Evacuation

- If an alarm sounds, evacuate the building and report immediately to the assembly area.

- Eating, drinking, and smoking are prohibited during evacuations and at the assembly area.

Emergency Exit Routes



Go to the assembly area when you exit for an emergency.

- **DO NOT LEAVE AREA**
- **NO FOOD OR DRINK**
- **NO SMOKING**
- **MINIMIZE TALKING**

WRTC Evacuation Assembly Area

After exiting the building during an emergency, assemble at the grassy knoll beside the front parking lot.

Lunchtime in White Rock

Gas Cylinder Safety

COURSE 9518

February 2017

Course Objectives

Recognize

- Common gas cylinder markings and labeling
- The components of a typical gas cylinder
- Hazards associated with gas cylinders and their contents
- Safe practices for gas cylinder handling, use, storage, and transport
- Resources for gas cylinder information and assistance
- How to safely inflate a balloon using a gas cylinder

Module 1 Objectives

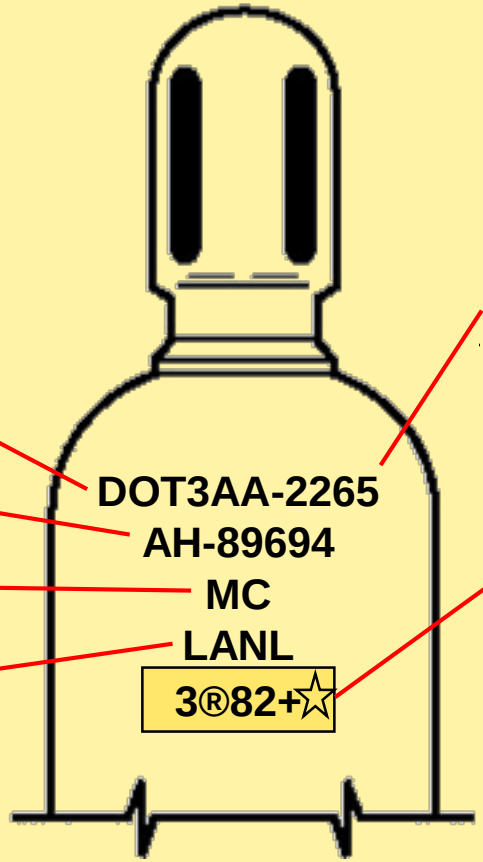
Recognize

- Gas cylinder specification markings
- Common components of gas cylinders
- That cylinder connections are determined by the family of gas a cylinder contains

Gas Cylinder Specifications

- Compressed gas cylinders are manufactured and tested in accordance with DOT regulations and CGA guidelines
- Cylinder lengths generally range from less than 2 to 5 feet. Cylinders up to 35 feet long are used on “tube trailers”
- Selection of cylinder size usually depends on the volume of gas needed for a particular task

Gas Cylinder Markings



DOT Specification (3AA)

Serial Number

Manufacturer's Symbol

Owner's Designation

Service Pressure (psig)

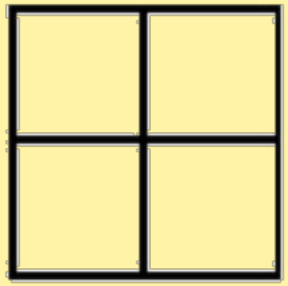
Test Date (3/82)
Original Tester's Symbol (®)
Permission to Overpressure by 10% (+)
Hydrostatic Retesting Extension Allowance (☆)

Additional Markings

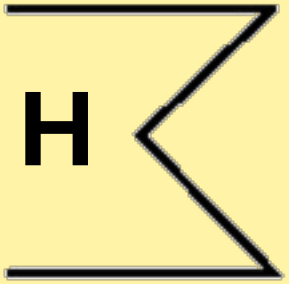
This symbol . . .	means that . . .
☆	the required interval for hydrostatic testing can be extended from 5 years to 10 years.
+	the cylinder can be filled to a pressure 10% greater than the cylinder's specified pressure.

What led to this?

Other Markings



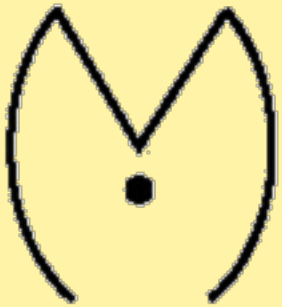
Linde



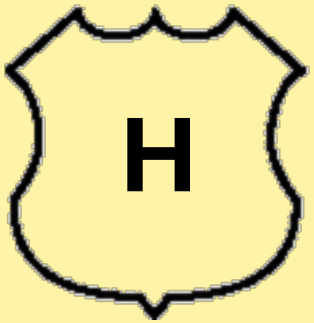
Holox?

Matheson?

Union Carbide-Linde

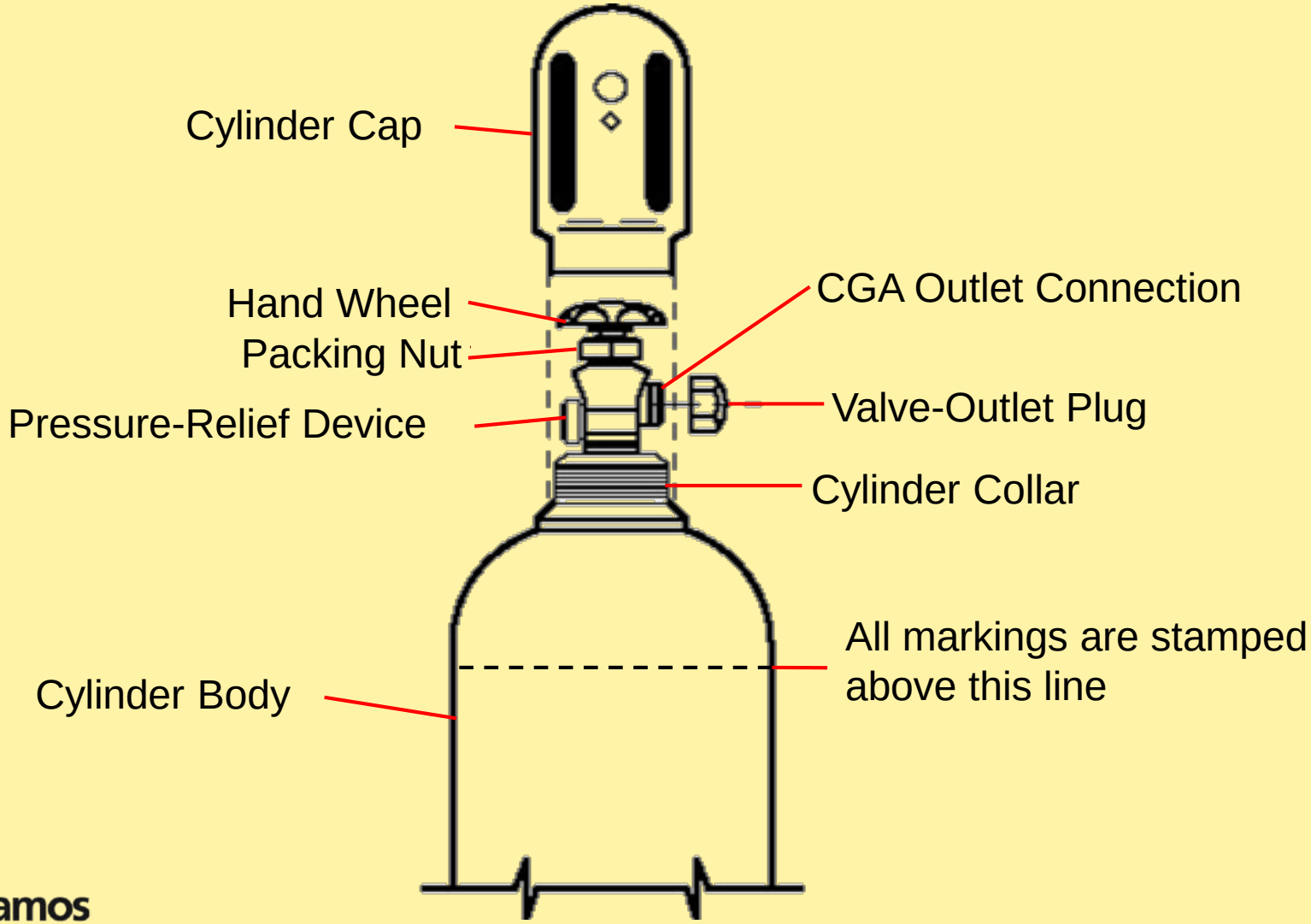


Matheson?

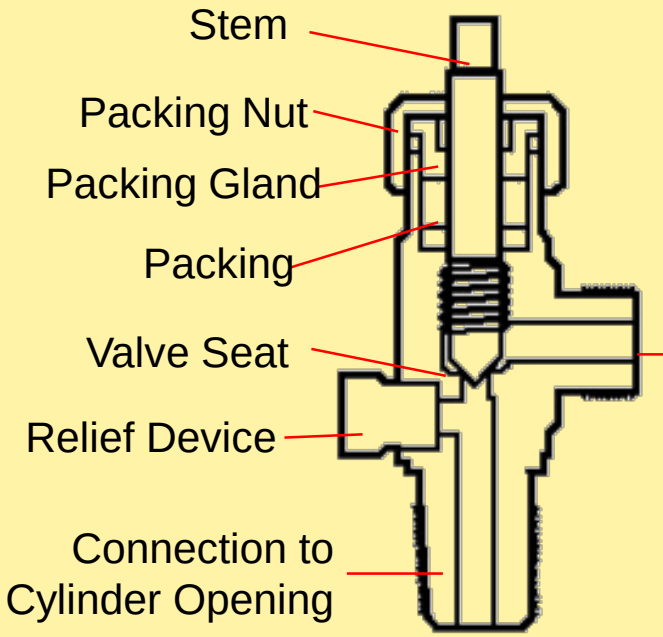


Holox?

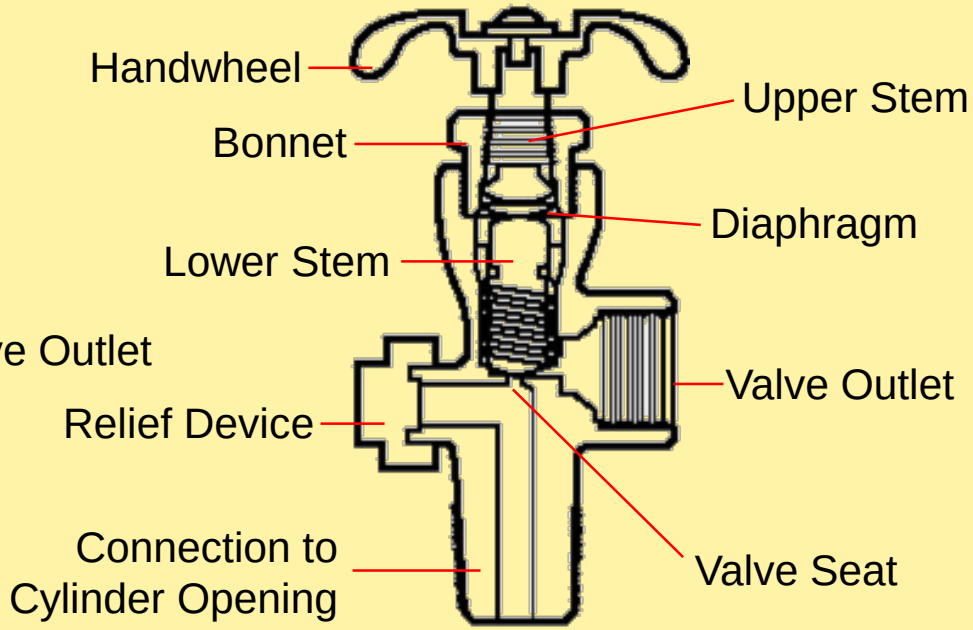
Gas Cylinder Components



Cylinder Valves—continued

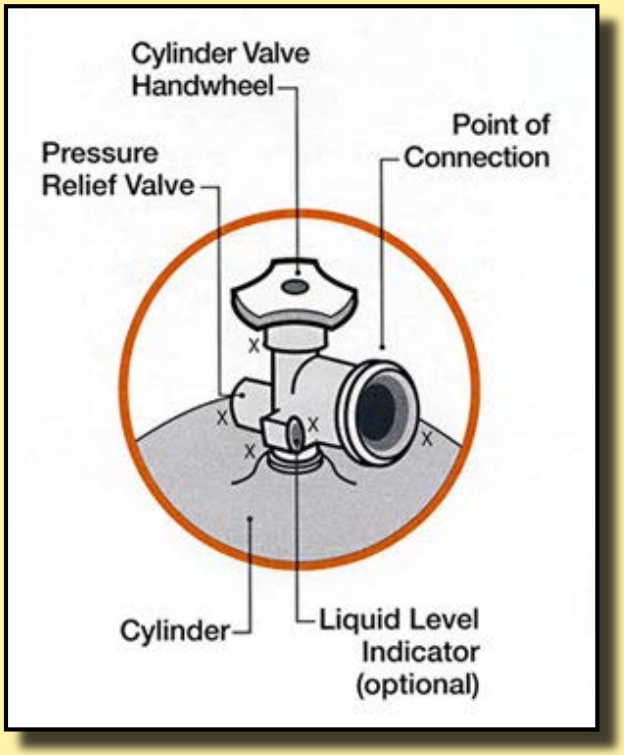


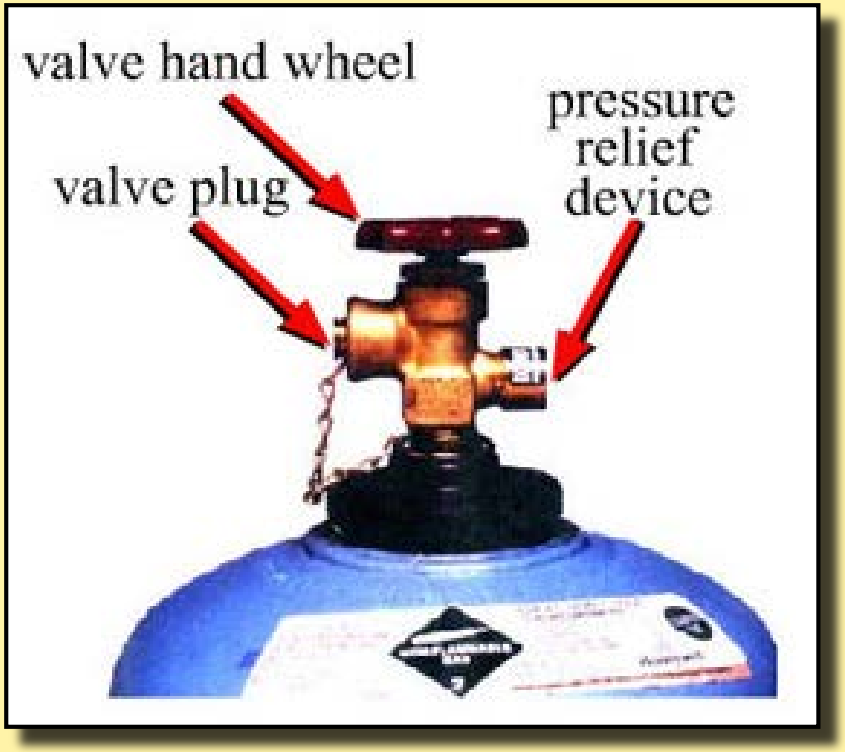
Packed Valve



Packless Diaphragm Valve

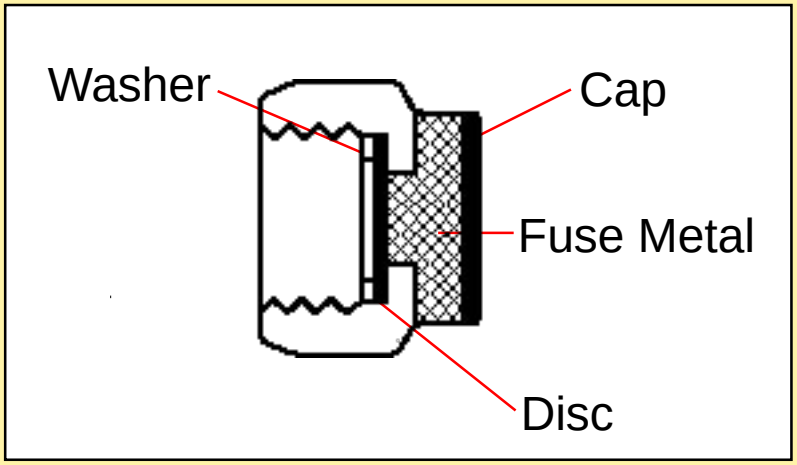
Cylinder Valves



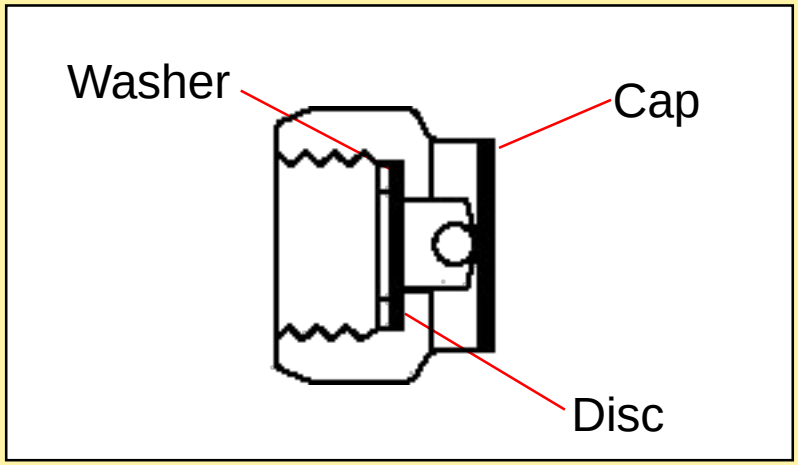


Cylinder Pressure-Relief Devices

Prevent catastrophic failure from an overly pressurized cylinder

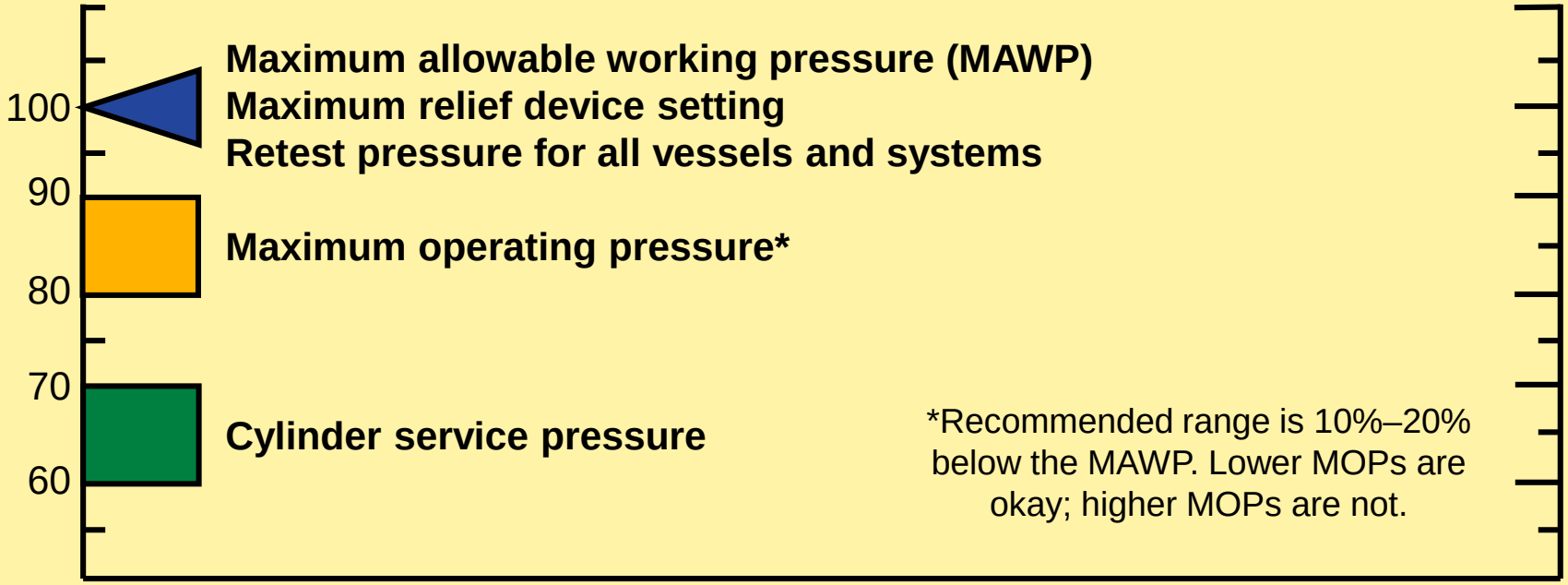


Plug and Disc



Disc Only

Pressure Levels



Source: DOE Pressure Safety Manual

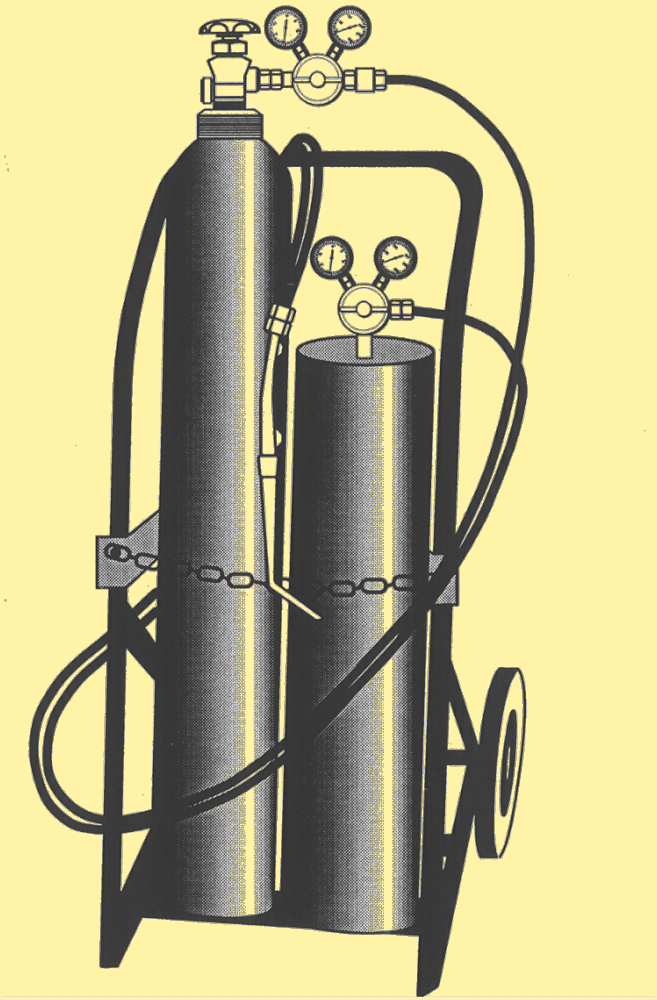
Video 1

Cylinder Connections

- To prevent unwanted reactions, the CGA specifies valve and regulator connections according to families of gases.
- To prevent mixing accidents,
  - Use only the regulators specified for the gas family you are handling
  - Never use an adaptor between a cylinder and a regulator to defeat the CGA system
  - Cylinder colors should NOT be used to identify contents

Video 2

Is This a Violation?



Module 2 Objectives

Recognize

- General hazards associated with gas cylinders, including pressure and oxygen-deficiency
- Hazards caused by the size and weight of some cylinders
- Hazards associated with the contents of gas cylinders

Pressure

- Gas cylinders at LANL are ~2100 psia
- Sudden depressurization can create a deadly projectile
- Overpressurization can create deadly shrapnel

Electrical arc damage

Oxygen Displacement

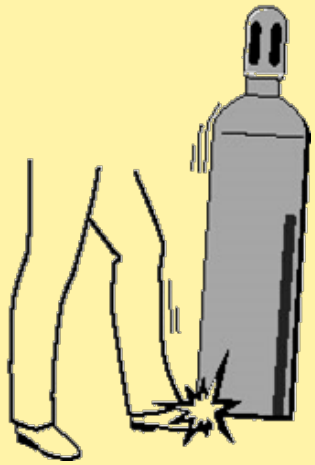
- Compressed gas that is released into the workplace can reduce oxygen to dangerous levels by displacement
- Where oxygen deficiency is a concern, air monitoring and alarms should be considered
- Never enter an oxygen-deficient atmosphere to try to rescue someone

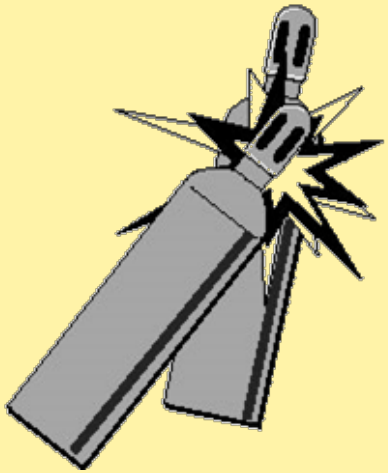
Reality

- Entry into an oxygen-deficient atmosphere is not like what you see in the movies.
- You can't go in unprotected, stagger around a while, save a couple of lives, and then exit coughing and unharmed.
- In such a situation, you will become just another victim.

Size & Weight Hazards

- Improper handling of cylinders can cause
  - Cylinders falling into each other
  - Cylinders damaging equipment
  - Crushing injuries to the body
  - Sprains, strains, and overexertion





Content Hazards

Manual pp. 15–18

- Oxidizing gases
- Flammable gases
- Poisonous gases
- Corrosive gases
- Cryogens

Oxidizing Gases

- Elevated oxygen levels enhance the ignitability and combustibility of materials.
- Flammable gases and oxidizers react violently when mixed and ignited.
- Store oxygen at least 20 feet from flammable/combustible materials, or use a 1/2-hour, 5-foot-high firewall.
- Keep oxygen containers, valves, regulators, hoses, and other cylinder parts free from oil and grease.

Note the "Use no oil" precaution

Flammable Gases

Proper Shipping Name	Class/ Division	UN Number
Acetylene, dissolved	2.1	UN1001
Carbon monoxide	2.3	UN1016
Deuterium, compressed	2.1	UN1957
Ethane	2.1	UN1035
Hydrogen, compressed	2.1	UN1049
Methane, compressed	2.1	UN1971
Propane	2.1	UN1978

DOT placard with a UN number

Post flammable-material storage areas with NO SMOKING signs.

Poisonous Gases

Proper Shipping Name	Class/ Division	UN Number	Hazard Zone
Carbon monoxide	2.3	UN1016	D
Chlorine	2.3	UN1017	B
Fluorine, compressed	2.3	UN1045	A
Hydrogen sulfide (H_2S)	2.3	UN1053	B
Phosgene	2.3	UN1076	A
Sulfur dioxide (SO_2)	2.3	UN1079	C

"Poison-inhalation hazards" are DOT Hazard Class/Division 2.3

Corrosive Gases

Proper Shipping Name	Class/ Division	UN Number	Hazard Zone
Ammonia	2.3(8)	UN1005	D
Hydrogen chloride, anhydrous	2.3(8)	UN1050	C
Trifluoroacetylchloride	2.3(8)	UN3057	D
Tungsten hexafluoride	2.3(8)	UN2196	D

- Corrosive gases degrade materials and bodily tissues
- DOT does not consider corrosivity to be the primary hazard
- Return cylinders with corrosive gases within 1 year

Cryogens

Proper Shipping Name	Class/ Division	UN Number
Argon, refrigerated liquid	2.2	UN1951
Helium, refrigerated liquid	2.2	UN1963
Hydrogen, refrigerated liquid	2.1	UN1966
Nitrogen, refrigerated liquid, cryogenic liquid	2.2	UN1977
Nitrogen, compressed	2.2	UN1066
Oxygen, refrigerated liquid	2.2	UN1073

Cryogens—continued

- Cryogenic containers (Dewars) are not rated for high pressure, but high pressure may occur if safe handling similar to that for gas cylinders is not practiced
- Cryogenic materials may cause cold burns
- Cryogen vaporization, having an expansion factor close to 1000 at an altitude of 7000 ft, displaces substantial breathable air
- For more information, register for Cryogen Safety (COURSE 8876)

Module 3 Objectives

Recognize

- Engineering controls and safe work practices for gas cylinder storage, handling, and use
- Controls for gas cylinder contents
- PPE for gas cylinder handling and use
- Safe work practices and the labeling and placarding requirements for gas cylinder transport
- Procurement, delivery, and return of gas cylinders at LANL
- Steps to take in the event of a gas cylinder release
- Resources for gas cylinder information and assistance

Engineering Controls

- Ventilation
- Enclosure
- Air Monitoring

Fume hood

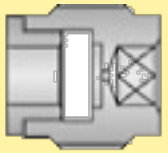
Gas detector

Oxygen sensor

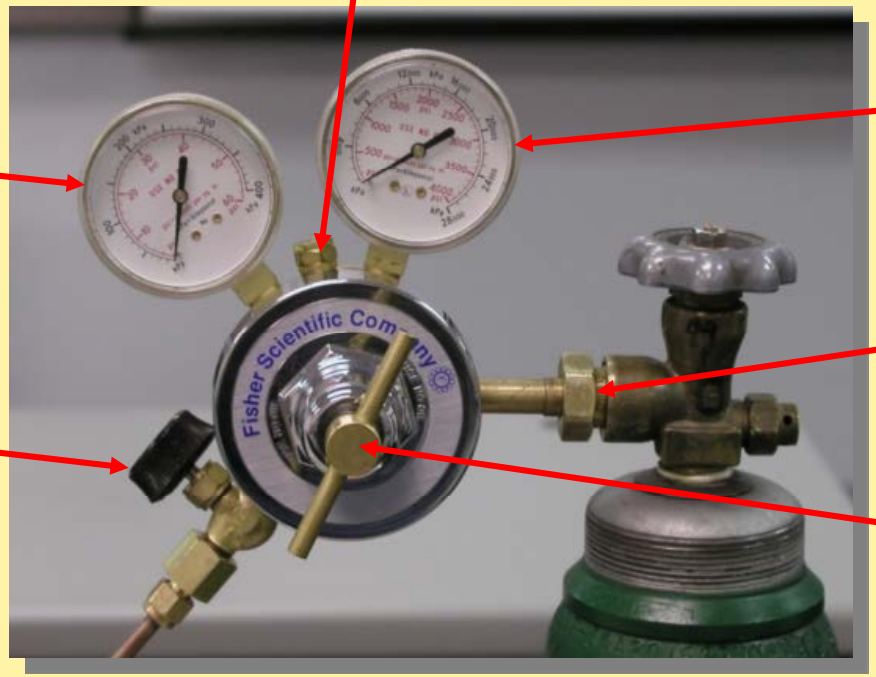
Gas cabinet

Engineering Controls—continued

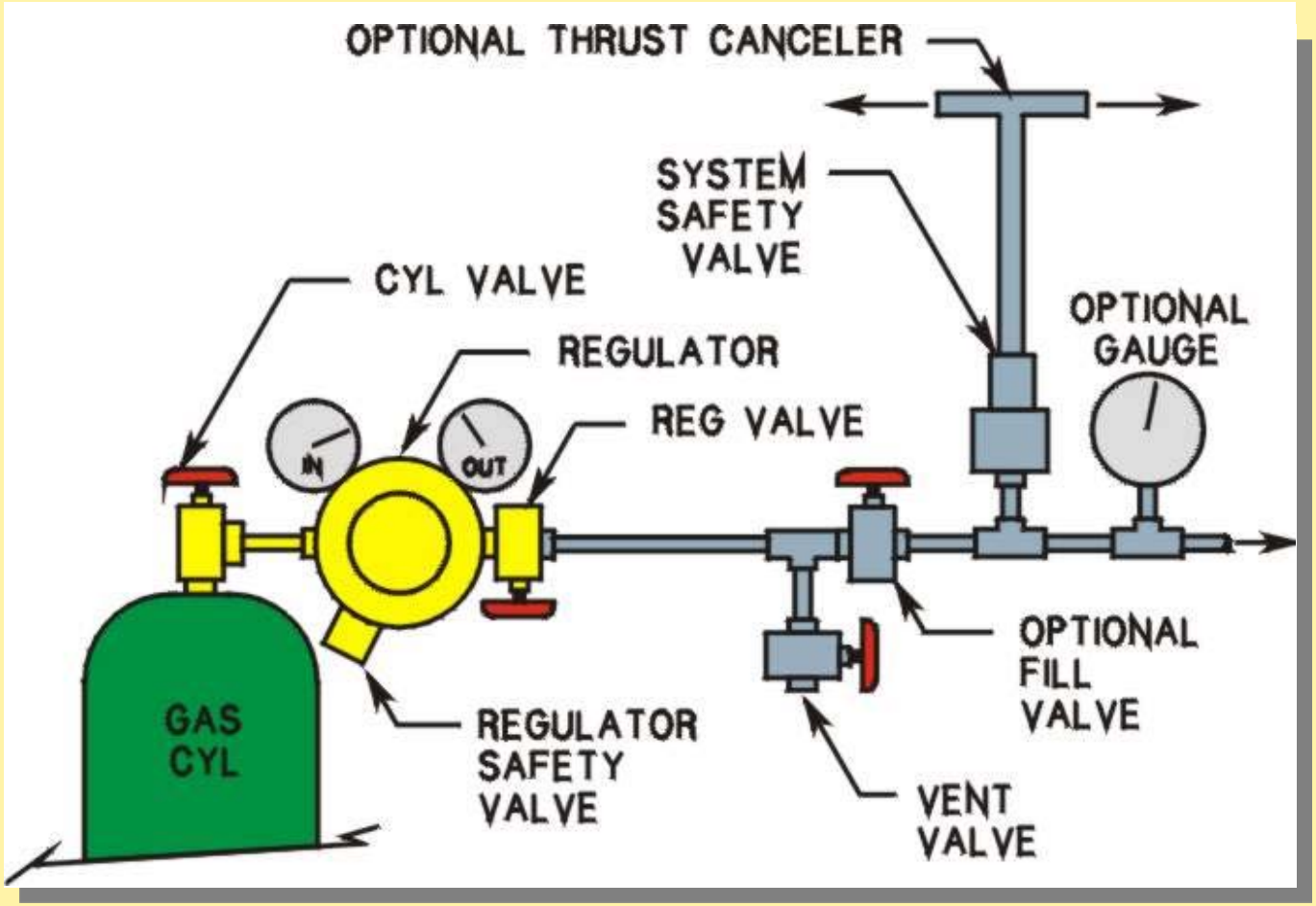
- Pressure Regulator
- Relief Device
- Restrictive Flow Orifice



Restrictive flow orifice



Engineering Controls—continued



Safety manifold

Gas Cylinder Storage

- Store cylinders in well-ventilated areas, away from extreme temperatures, moisture, corrosives, or objects that may strike or fall on them
- Secure cylinders upright in racks during storage (and use)

LANL Gas Plant

Gas Cylinder Storage—continued

- Store cylinders outdoors in locked structures or in continuously vented hoods
- Post your compressed gas storage area with appropriate hazard signs

Gas Cylinder Storage—continued

- Segregate cylinders as necessary
- Keep valve-outlet plugs in place and cylinder caps on
- Keep valves closed when cylinders are “empty” or not in use
- Never store acetylene cylinders on their side!

Gas Cylinder Handling and Use

- Be aware of adjacent operations
- Move cylinders on approved handcarts, secured with straps or chains; do not roll or drag cylinders, and use care when lifting
- Never lift cylinders by their caps
- Use components that are compatible with the gas you are using
- Open cylinder valves slowly, and never use excessive force to open valves

Gas Cylinder Handling and Use—continued

- Check for leaking cylinders
  - Thermal conductivity leak detector
  - Flammable gas detector
  - Soap solution
  - Inert gas test
  - Never try to repair a leaking cylinder!!!

- Avoid prolonged, rapid depressurization of a gas cylinder
- Vent gases away from air intakes

Controls for Cylinder-Content Hazards

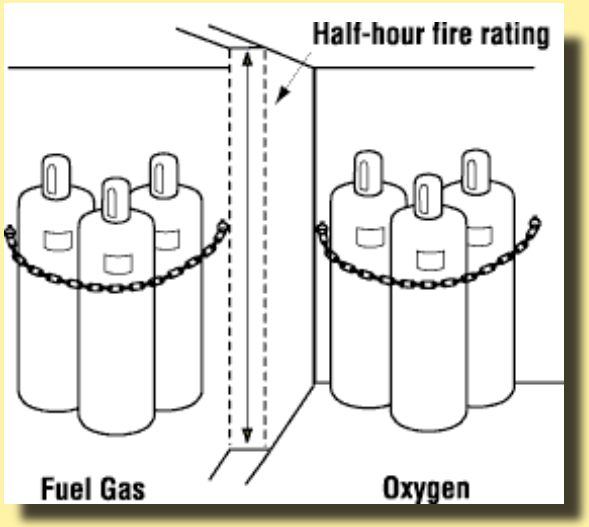
As with any workplace hazards, before you begin work, familiarize yourself with the location, requirements, and operation of

- Applicable work documents, usually an IWD
- Eyewash/safety shower
- SDSs
- Fire extinguisher(s)
- Alarm pulls and exit routes

Controls for Cylinder-Content Hazards—continued

Minimize contact between oxidizers, reactives, and flammables:

- Maintain 20-foot separation or a 1/2-hour firewall for storage areas
- Check valves to prevent the mixing of reactive gases
- Ensure that regulators and fittings are appropriate for each family of gases
- Keep oxygen equipment free of oil and grease



Check valve

Controls for Cylinder-Content Hazards—continued

- Post flammable storage areas with "No Smoking" signs
- For acetylene gas cylinders, leave the valve key on the cylinder valve during use and open the valve no more than one full turn
- To minimize poison gas hazards:
  - Use less-toxic substitutes whenever possible
  - Order the smallest quantity needed
- Locate poison, corrosive, and reactive gas cylinders in an exhausted enclosure. Use an RFO, if possible.

Acetylene cylinder valve

Personal Protective Equipment

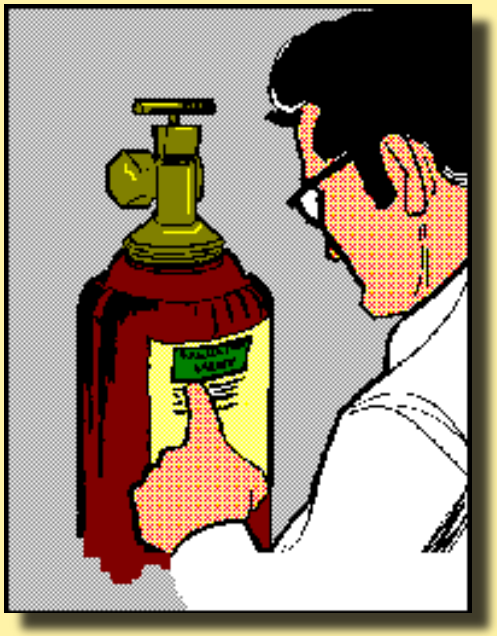
- Wear safety glasses when working with or around gas cylinders
- Wear foot protection when handling gas cylinders
- Wear additional PPE, depending on the task and the cylinder contents

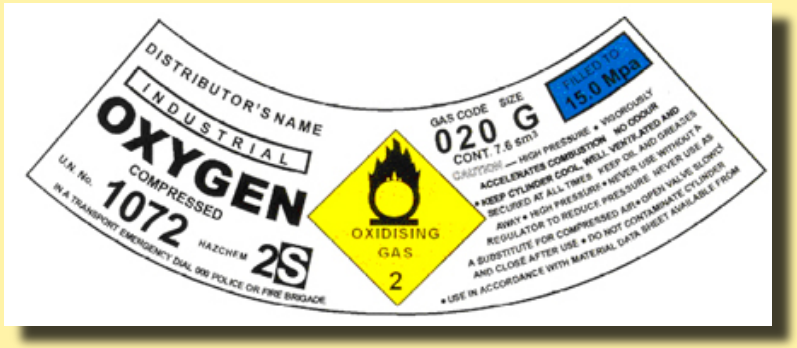
Gas Cylinder Transport

- Remove regulator; keep cylinder cap and valve outlet plug in place
- Secure cylinders upright whenever possible
- Transport cylinders in open trucks, never inside truck cabs or automobiles (exception for fire extinguishers), or else

Gas Cylinder Transport—continued

- Hazardous Material Transfer Forms (HMTFs), labels, and sometimes placards must accompany cylinder shipments
- An HMTF contains information on the hazard and the hazard zone
- Labels are required to communicate cylinder-content hazard information





Gas Cylinder Transport—continued

Placards are required

- on vehicles if the gross weight of the cylinders and their contents exceeds 1000 pounds
- for any quantity of Class/Division 2.3 poison gas
- to be clearly visible on all four sides of the transport vehicle

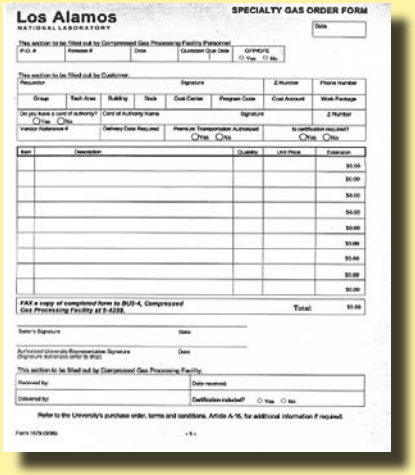
Three DOT divisions of compressed gas placards

Procurement, Delivery, and Return

Workers at the gas plant

- Refill gas cylinders and deliver them to your facility
- Deliver larger volumes of gases in tube trailers
- Supply specialty gases from vendors
- Pick up “empty” cylinders

LANL Gas Plant



Note: *Authorization from your supervisor is required before ordering cylinders.*

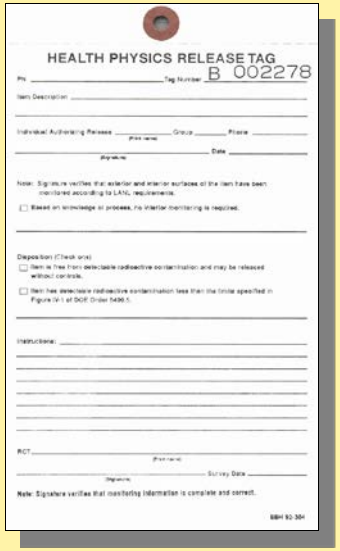
Procurement, Delivery, & Return—continued

- For cylinder delivery, keep your delivery point clean, water-free, snow-free, and accessible
- If HMPT trained and picking up cylinders, use ONLY open government vehicles with racks or restraints
- Cylinders for return should
  - contain at least 25 psig of pressure to prevent contamination
  - be disconnected, standing, and secured, with their caps in place

Procurement, Delivery, & Return—continued

Cylinder return

- Use “return” tags
- Write special notations on the tags, not the cylinders
- For flammable or poisonous gases, use valve-outlet plugs
- For cylinders used in radiological contamination areas, have a health physics release tag



Accidental or Uncontrolled Releases

1. Evacuate the area
2. Call 911; stay on the line to provide information
3. Notify your supervisor
4. Monitor the air in the work area before reentering

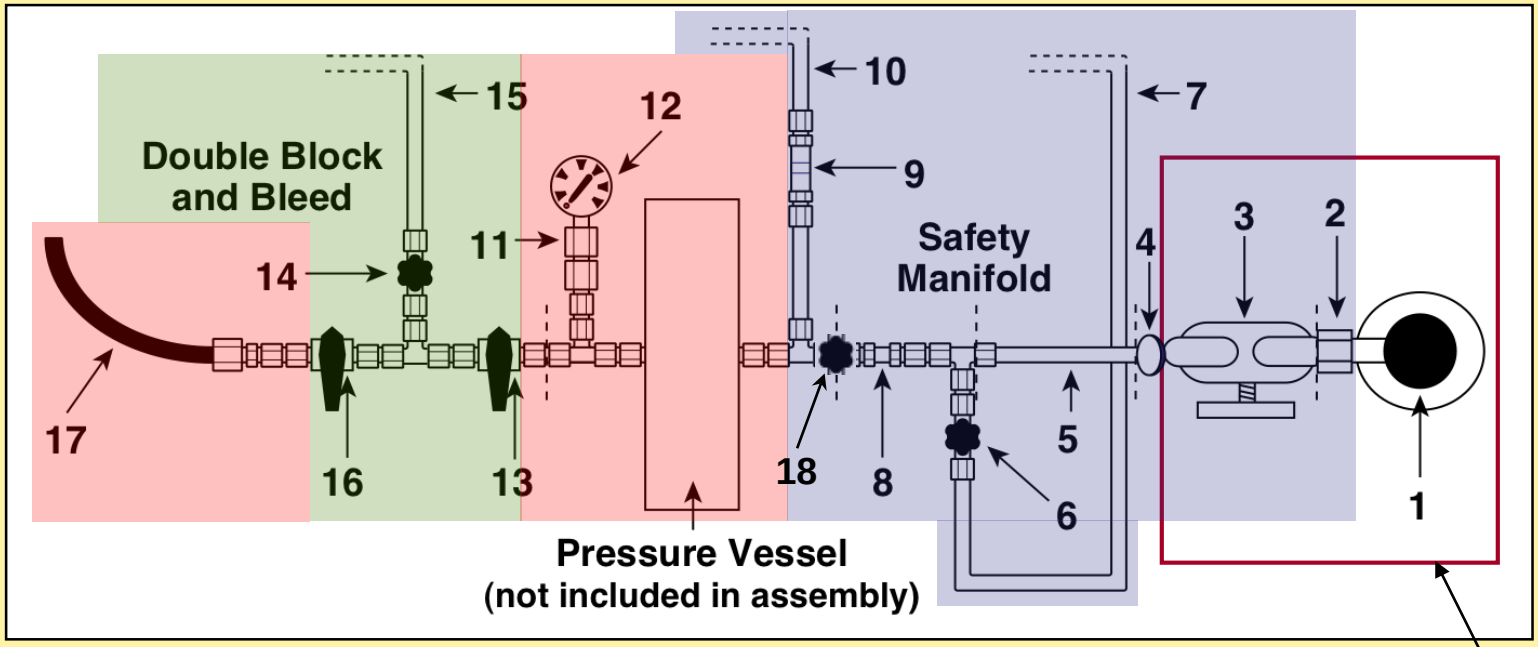
Gas Cylinder Information and Assistance

For information or assistance on . . .	call . . .	at . . .
The packaging and transport of gas cylinders	Packaging and Transportation (“The Gas Plant”	7-4406
The design, installation, inspection, and safe use of pressurized systems	Industrial Hygiene & Safety	6-0295
Orphaned cylinders	Emergency Operations	7-6211
Training on pressure safety and related topics	Institutional Training Services	7-0059

If you find an orphaned cylinder,
DO NOT call the Gas Plant! Call 7-6211.

Activity: Pressure System Assembly

Manual p. 31–32



1 Cylinder
2 CGA connection
3 Regulator
4 Regulator fill valve
5 Down tube
6 Vent valve
7 Vent tube
8 Check valve
9 Pressure-relief device
10 Vent tube
11 Snubber
12 System gauge
13 Blocking valve
14 Vent tube
15 Vent tube
16 Blocking valve
17 Pigtail
18 Fill valve

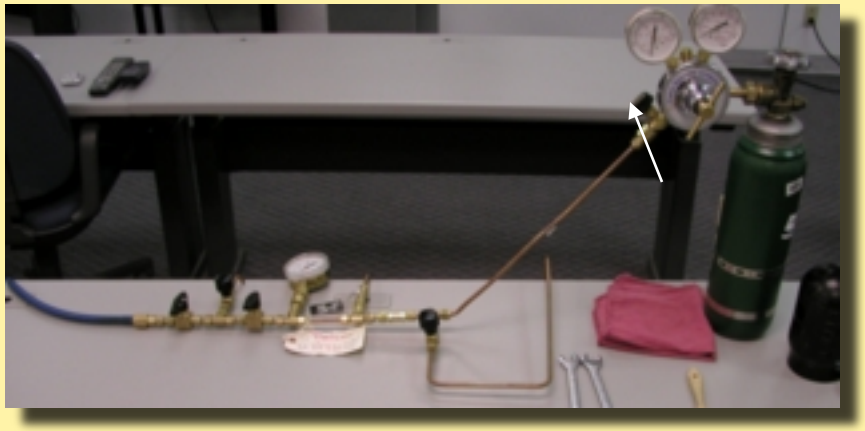
To be connected

Activity: Pressure Assembly System

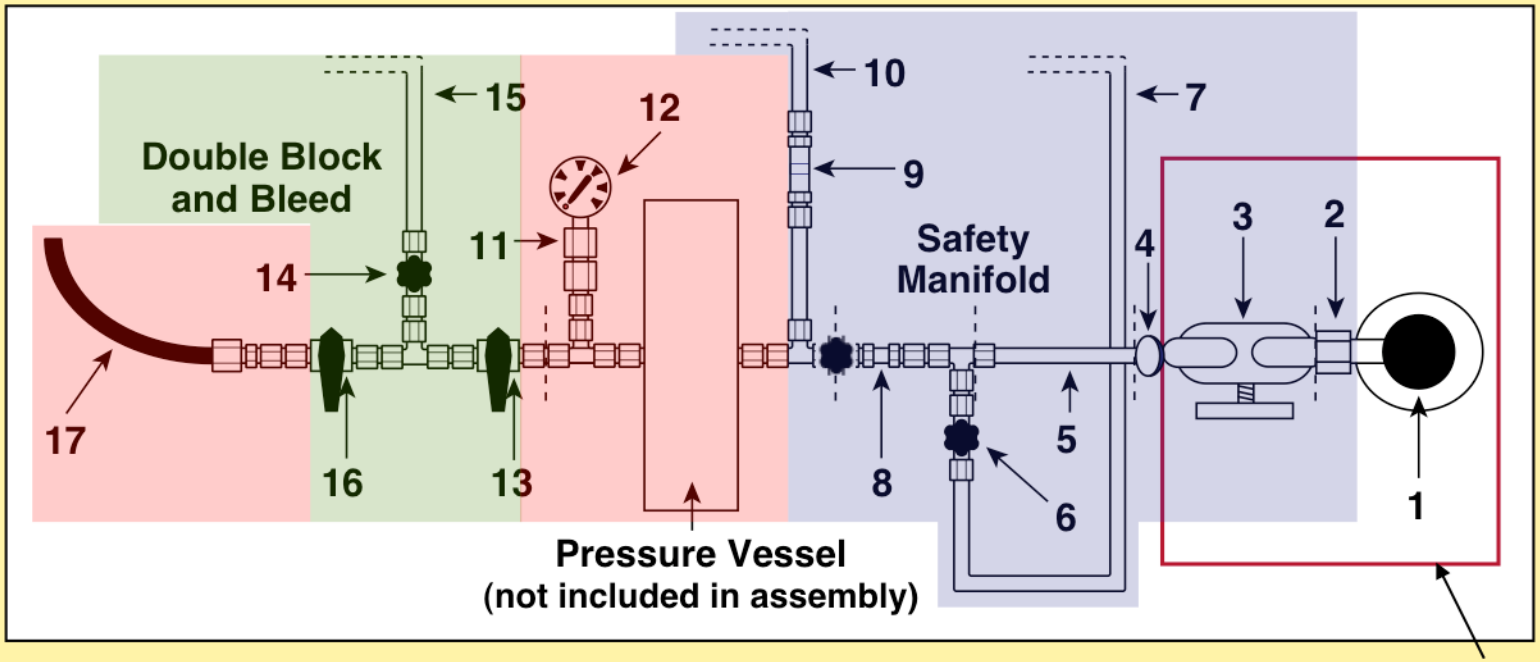
Tightening the SWAGELOK fittings

- Hand-tighten after carefully aligning the threads of the nut onto the body
- Wrench-tighten with two wrenches (backup wrench on body) about 1/10 of a turn

Note: *These instructions apply only to this classroom activity. New fittings require a special procedure. Attend Compression Fittings Assembly (Course 30831).*



Activity: Pressure System Assembly



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15 Vent tube
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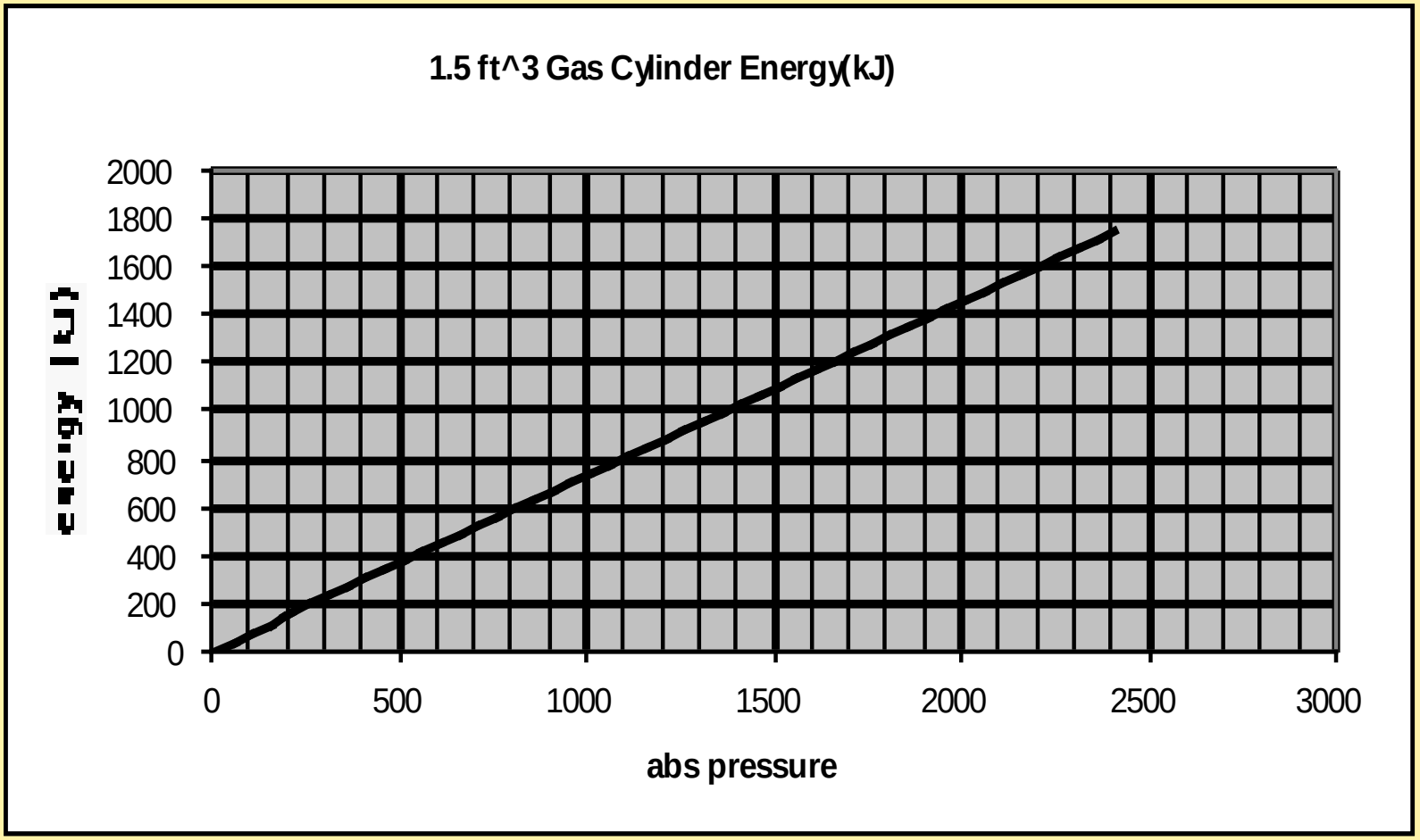
End of Presentation

Questions and Comments


1.5 ft^3 Gas Cylinder Energy(kJ)
energy (kJ)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000
abs pressure

Gas Cylinder Accident

49 CFR 177.840, Carriage by Public Highway, Class 2 (gases) materials addresses the handling and transportation of compressed gas cylinders. Specifically, subpart 840 states that cylinders "must be securely restrained in an upright position, loaded in racks, or packed in boxes or crates and securely attached to the motor vehicle to prevent the cylinders from being shifted, overturned, or ejected from the vehicle under normal transportation conditions."

An Acetylene Incident

- In Newcastle, England, a fitter left a cylinder of acetylene in the cab of his truck. The acetylene cylinder leaked (it may not have been fully closed) and accumulated in the truck over the weekend.
- On Monday morning, when the fitter opened the truck door, a large explosion took place. Ignition may have been caused by the internal light, the automatic door control, or by a mobile phone, which was on the front seat. The fitter received injuries to his eardrums and face.
  - Acetylene
  - Flammability range (% by volume in air): LEL 2.5% UEL 100%
  - Precaution: Use or store only in a well-ventilated area.
  - NFPA ratings: Health 1, Flammability 4, Reactivity 3

Why we don’t place compressed gas in a closed vehicle . . .

Why we don’t place compressed gas in a closed vehicle . . .

Why we don’t place compressed gas in a closed vehicle . . .