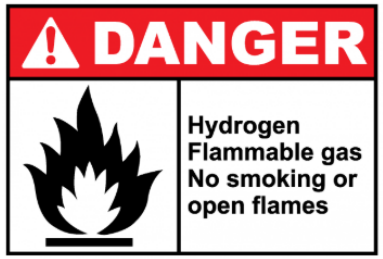
M_002: Compressed Gas Safety Training



About this training

- **Description:**
  - **Review of compressed gas hazards; safe work practices; personal protective equipment (PPE); standard operating procedures; gas inventory management and a tool to evaluate, identify and eliminate compressed gas hazards**

- **Required Participants**
  - **Persons who work with or handle compressed gas cylinders, or utilize and assemble approved gas systems.**

Contact the LLE Safety Team with your questions and concerns.

Evolution of Compressed Gas Safety - Accident of 2008

The U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) cited the University of Rochester Laboratory for Laser Energetics for 9 serious safety violations that caused Aug. 6, 2008 accident that seriously injured an employee. The laboratory was closed for 3 weeks. In the months to come, the LLE Safety Department reevaluated its training program. As a result, many new training modules were formed; including Compressed Gas Safety.

What happened: The employee was servicing a pressurized diagnostic device for the OMEGA laser known as the "Light Pipe" when it exploded. OSHA's inspection found deficiencies regarding the design, installation, and operator training for the Light Pipe and the compressed gas system of which it was a part.

OSHA cited the lab for failing to safeguard employees against recognized explosion hazards associated with assembly, disassembly, pressurizing, evacuating, and monitoring activities for the Light Pipe. It had also been cited for failing to keep the Light Pipe gas tight or provide it with a pressure relief device to prevent an instantaneous uncontrolled gas leak; failing to have the compressed gas system designed by a competent person; an improper gas pressure regulating device; housing the compressed gas cylinder in a place where it was exposed to damage; improper installation of the platform plate from which the Light Pipe was attached; having unqualified persons work on the compressed gas system; lack of eye, face and hand protection; and not evaluating the work area for hazards.

Outline

- Overview
- Resources
- Hazards
- Compressed Gas Systems
- Compressed Gas Cylinder Management
- PPE
- Summary

Safety is everyone's business and compliance with safety procedures is MANDATORY

- All new gas delivery systems and attached equipment must be inspected and approved by Mechanical Engineering (ME) prior to operation
- Flammable gas systems require extra safety measures and will be evaluated on a case-by-case basis by the LLE safety officers and the gas products supplier
- All gas systems users must follow standard operating procedures for basic systems in this document, or develop written procedures appropriate for circumstances
- Know the hazards associated with the gases being used
- Always use the proper Personal Protective Equipment (PPE)

Evaluate, identify and eliminate compressed gas hazards

Resources

OSHA Standards for Compressed Gas

Compressed Gas and Equipment

- Standards
- Hazard Recognition
- Hazard Evaluation and Control
- Additional Resources
- **Workers' Rights**

Standards

Compressed gas and equipment is addressed in specific OSHA standards for general industry, maritime, and construction. This section highlights OSHA standards and documents related to compressed gas and equipment.

OSHA Standards

General Industry (29 CFR 1910)		Related Information
1910 Subpart H - Hazardous Materials	1910.101, Compressed gases (general requirements).	Related Information
	1910.102, Acetylene.	Related Information
	1910.103, Hydrogen.	Related Information
	1910.104, Oxygen.	Related Information
	1910.105, Nitrous oxide.	Related Information
1910 Subpart M - Compressed Gas and Compressed Air Equipment	1910.169, Air receivers.	Related Information
1910 Subpart Q - Welding, Cutting and Brazing	1910.253, Oxygen-fuel gas welding and cutting.	Related Information
	1910.254, Arc welding and cutting.	Related Information
1910 Subpart T - Commercial Diving Operations	1910.430, Equipment.	Related Information

https://www.osha.gov/compressed-gas-equipment/standards

Evaluate, identify and eliminate compressed gas hazards

The personnel hazards associated with gases

- Stored (potential) energy can cause injury from rapid pressure release
- Asphyxiation from oxygen displacement. The most common risk to personnel is nitrogen since it accounts for most of the gas used at LLE (others include helium, argon, CO2, SF6, …)
- Flammable gas systems must be evaluated on a case-by-case basis by the LLE safety officers
- Oxidizers can support and vigorously accelerate combustion in the presence of an ignition source and a fuel (e.g., oxygen)
- Pyrophoric gases with an autoignition temperature in air below 130°F (e.g., acetylene)
- Corrosive or Toxic gases must be used in fume hoods to protect personnel and gas-handling equipment must be designed to resist failure from corrosion

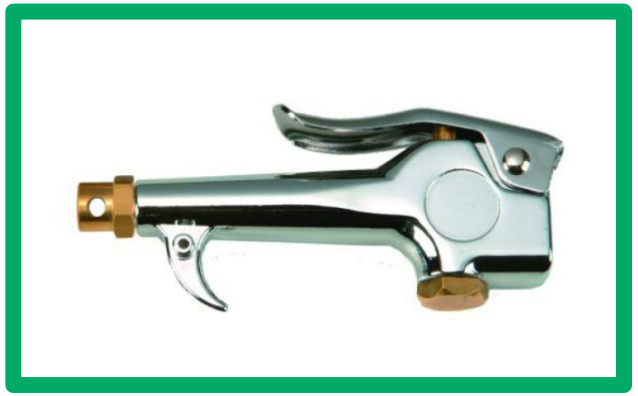
Read and understand the Safety Data Sheets (SDS) for each gas type used

Compressed air/nitrogen safety

- **Compressed air used for cleaning shall be limited to a maximum pressure of 30 psig (this refers to parts and not your person)**
- **PPE - Always wear goggles to protect your eyes**
- **Do not use compressed air to clean clothing; the air jet tends to drive particles into the fabric, where they can cause skin irritation. Keep a clothes brush handy or, preferably, wear a lab coat. (Per OSHA 1917.154)**
- **Never aim an air stream at another person**
- **Never apply air pressure to the body (air embolism)**
- **Do not substitute compressed oxygen for air. Clothing saturated with oxygen burns explosively**

Compressed air/nitrogen safety – gas embolism

- **Many laboratories throughout the lab are equipped with “house” air or Nitrogen. Utilization of these sources that involve the use of an air nozzle should only be done when it is equipped with a safety tip nozzle**
- **Embolisms can occur when an gas source is applied directly to the body**
- **An embolism occurs when air bubbles enter a vein or artery and block it creating a potentially serious condition.**
- **These air bubbles can travel to your brain, heart, or lungs and cause a heart attack, stroke, or respiratory failure.**



With safety tip nozzle

Without safety tip nozzle

Air an Nitrogen are examples of gases that that can cause an embolism

Gas system definitions

- **Maximum Operating Pressure (MOP)**
  - **The maximum pressure at which a vessel or system is normally allowed to operate**
  - **MOP is the Do-Not-Exceed pressure for normal operation**
  - **It is not a code-calculated strength limit; it's an operational limit**
  - **In simple terms…MOP is "the pressure where the system is chosen to be run"**
  - **MOP < MAWP**

- **Maximum Allowed Working Pressure (MAWP)**
  - **The highest internal pressure a pressure vessel, pipeline, or component is designed to safely handle at its operating temperature based on code-rated limits**
  - **Calculations are based on the least robust component in the entire system at operating temperature**
  - **Pressure Relief Valves (PRV) are typically set at or below the MAWP value**
  - **In simple terms…"This is the max pressure the hardware can legally handle"**

Never operate a gas system in excess of the Maximum Operating Pressure

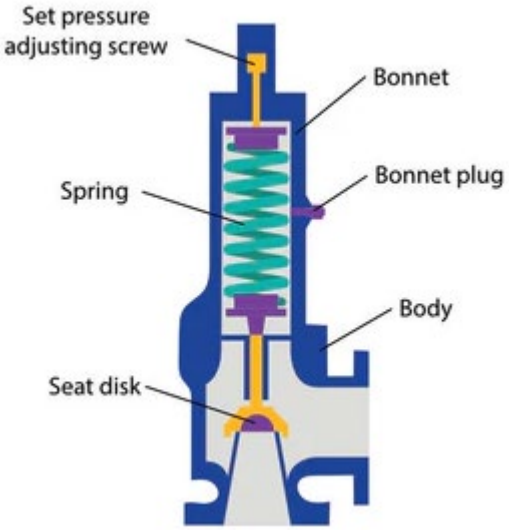
Pressure Relief Devices – PRD's (Pressure Relief Valves, PRV's)

A gas pressure relief valve is a safety device that automatically releases excess gas pressure to prevent system damage or explosion. It operates by venting gas to the atmosphere when the system pressure exceeds a preset limit, and then automatically reseals when the pressure returns to a safe level. These valves are crucial for over-pressure protection in a wide range of applications.

Basic types of PRD's

a) **Conventional Spring loaded - (most common)**
   - -can be adjustable or permanently set
   - -relieve pressure at set pressure point

b) **Rupture Disk – (common on gas bottles)**
   - -one time use – not resettable
   - -relieves pressure all at once when disk breaks or ruptures



CONVENTIONAL SPRING LOADED PRESSURE RELIEF VALVE

Compressed gas systems must employ PRV's to insure the safety of the operator and the equipment. Consult with the Mechanical Engineering department for proper sizing and placement

Considerations of a compressed gas system

- **Assess gas and site-specific hazards, including:**
  - **Required operating pressure and pressure rating(s) of all attached equipment & components**
  - **Gas properties: toxicity, flammability etc.**
  - **Access (public vs restricted)**
  - **Emergency egress**
  - **Potential gas concentrations resulting from sudden release, etc.**
  - **Identified hazards must be adequately mitigated.**

Prior to ordering and purchasing equipment, review with mechanical safety with any questions

Compressed Gas Regulators

- **Regulator selection is highly dependent upon the application**
- **Selection of a regulator is influenced by the following factors:**
  - **Type of gas being used (inert, flammable, oxidizer, corrosive etc.)**
  - **Grade of gas being used**
  - **Cylinder pressure and delivery pressure**
  - **Flow capacity**

Contact MSO if you need help selecting a regulator suitable for your application

- **Use care when installing regulators and valves on flammable gas cylinders. Many use left-handed threads to prevent them from being interchanged with oxidizing gases.**
- **Cylinder valves are meant for turning the gas on or off. The regulator is used to control pressure and flow**
- **Leak test gas systems with inert products such as SNOOP or use an electronic leak tester. Soaps and other products might leave organic residue or corrode regulator components**

Never attempt to modify or repair any component of a regulator
Remove from service immediately

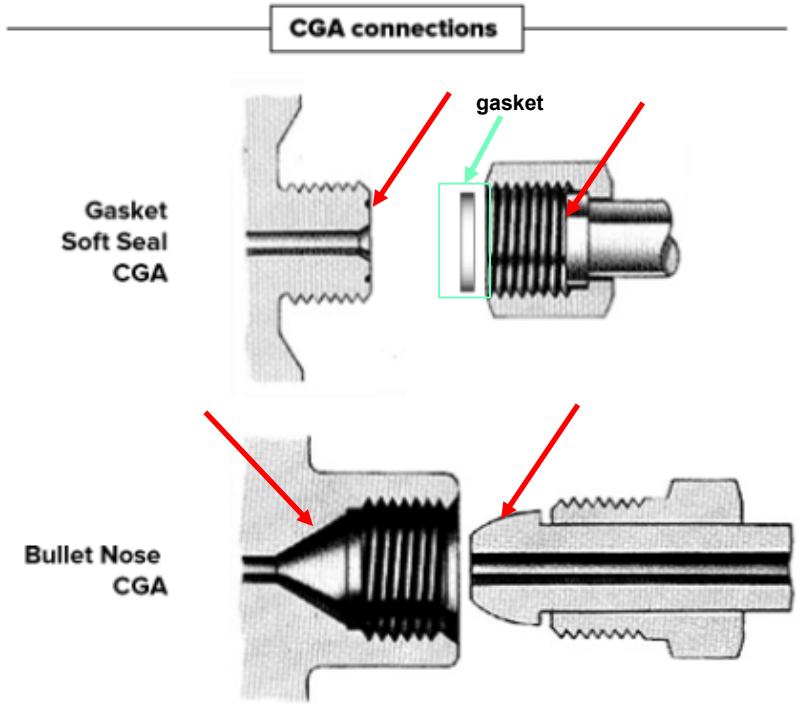
Components of a Regulator and Compressed Gas Cylinder

*CGA = Compressed Gas Association (standards org.)
*PRD = Pressure Relief Device

CGA connections (Compressed Gas Association)

Threads don't make the seal – they mate the joints that make the seal

- **Most typical connection is the "bullet nose connection"**
- **Do not use Teflon tape on a CGA connection…It will not work to make a proper seal.**
- **Flammable CGA connections utilize a left handed thread**
- **Do not make thread on adaptions to a CGA thread connection!**



Sealing surfaces are noted by red arrows

High Pressure Bottle Compressed Gas System Guidelines

- **Always utilize a cylinder strap and bracket to attach the bottle to an immovable object at the point of use**
- **Inspect the regulator and cylinder connection for damage before attachment and use**
- **Never use lubricants, Teflon tape, or other sealants on a CGA connection**
- **Never interchange vacuum fittings with high pressure fittings unless otherwise specified by the manufacturer**
- **All fittings and corresponding hardware including tubing, piping, etc. must be used per the manufacturer's specified recommendations. This includes pressure ratings and material compatibility with the specified gas**

Never attempt to modify or repair any component of a regulator
Remove from service immediately

Proper Gas Cylinder Storage

Cylinders must be securely attached upright to a fixed support

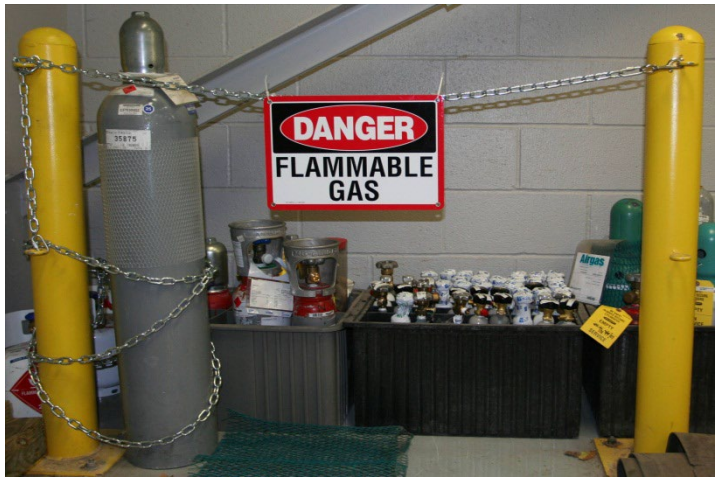
Store cylinders with a safety cap installed (when designed for one)

Cylinders must have a legible label – if they do not, return to gas supplier

Gas cylinder storage at LLE consists of two separate areas in Shipping and Receiving (S&R) area

- **Flammable gases must be stored at least 20 ft away from any oxidizing gases or gas mixtures**
- **Flammable gases and gas mixtures must be used and stored in a well-ventilated area that is readily accessible in case of emergency**

Flammable gas storage



≥ 20 ft

Nonflammable gas storage

Spark-proof* tools must be used when utilizing flammable gases

*spark-proof tools are made from non-ferrous materials such as Bronze and Aluminum

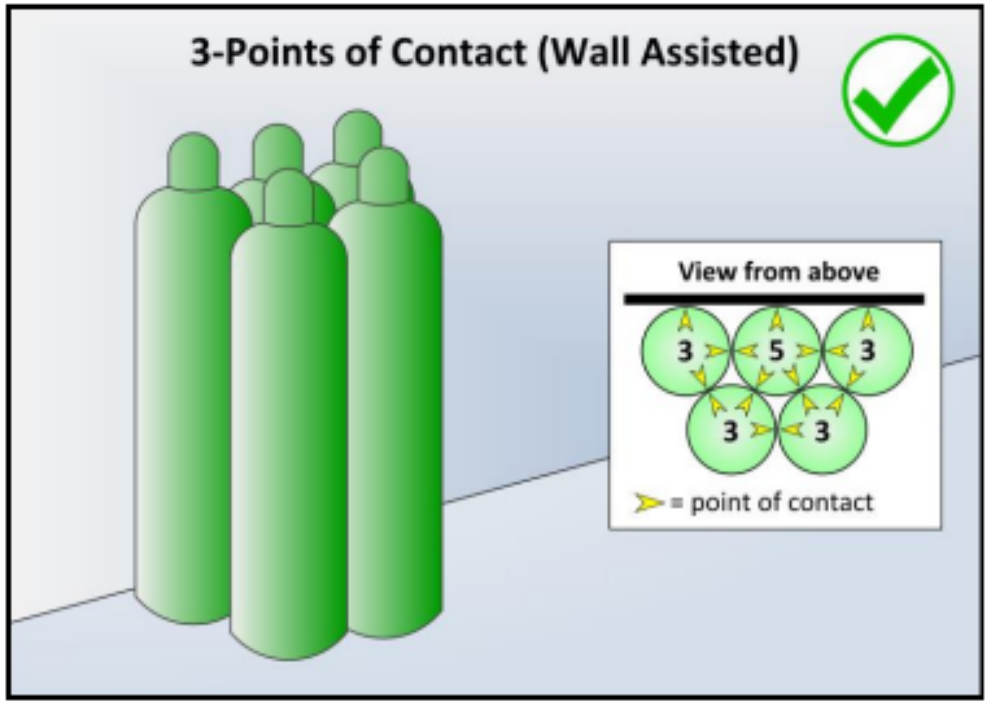
Store gas cylinders in Shipping and Receiving until they are put into service

- **Return gas cylinders to Shipping and Receiving in designated locations when they are removed from service**
- **Secure cylinders in the upright position to a wall bracket or bench clamp are at least three points of contact**
- **Segregate and appropriately label empty and full cylinders**
- **Only one cylinder per strap is permitted in lab spaces**

Cylinders will remain ‘stored’ in shipping until they need to be used: <u>do not store cylinders in labs</u>

Cylinder nesting

- **Cylinder nesting should only be implemented when *absolutely necessary***
  - **requires three points of contact per cylinder**



Above represents an appropriate grouping of cylinders to maintain three points of contact when assisted by a wall.

All gas cylinders must have a label indicating the usage status of the cylinder

- When cylinder arrives at LLE, put your name and date on the top of the label
- After placing a cylinder in service, rip off the “Full” tab
- When pressure is insufficient for continued use, rip off the “In Service” tab and return to the appropriate “Empties” location in Shipping & Receiving according to signage, even if this requires moving other cylinders

Basic steps for moving a gas cylinder to and from point of use

- Check the cylinder label for proper contents (and certification sheets, if available)
- Wear safety shoes and eyewear while moving cylinders
- Keep cylinder cap on during transport and storage
- If cylinder is too heavy, ask for help
- Do not subject cylinders to abnormal mechanical shock that could damage the valve, safety devices or the cylinder

If any cylinder is suspected of leaking, leave the area immediately and have the Shipping and Receiving staff contact the supplier

These rules must be followed when moving gas cylinders

- Cylinders should never be dragged
- NEVER lift a cylinder by the cap
- Move cylinders in an upright position by using a suitable cylinder cart or hand truck
- Large cylinders must always be strapped to a cart
- Never move the cylinder without a cap installed, if it's designed for one
- Never move the cylinder with a regulator attached
- Small cylinders up to 50lbs may be moved on a cart that has sides to prevent them from rolling off

FOLDABLE REAR ASSEMBLY WITH
LARGE 4" CASTERS

NO. 6114
HEIGHT: 46" DEPTH: 15" (O.D.)
WIDTH: 15" (O.D.) WEIGHT: 30 lbs.
WHEEL DIA: 10" x 1.75" SOLID RUBBER
CASTER: 4" x 1" SWIVEL / POST
SINGLE CYLINDER

Never lift a gas cylinder by the cap
(the cap is not a load bearing lifting point)

Securing Compressed Gas Cylinders- Cylinder Straps and Brackets

- Cylinder brackets can be found online through multiple outlets such as McMaster Carr, MSC, and Grainger
- Brackets may be attached to walls and other objects such as optical tables
- Use only approved brackets and hardware
- Ask the ME safety team if help is needed

Gas cylinders must be strapped to an immovable object for permanent installations

Temporary installation

- **Temporary installations must be approved by a safety officer and be secured to a 4-wheeled cylinder truck**
  - **Liquified gases may not be used in this manner**
- **Any time a cylinder is on a truck and unattended in a public area, it must have a legible label**
- **Stanchions or barriers shall limit access within 36” of the cylinder**

Temporary gas cylinder installation

Start Date: _____ Planned End Date: _____

Responsible Person: _____

Cell #: _____

Avoid using lecture bottles whenever possible

- **Lecture bottles cost approximately $1000.00 to dispose of and should only be used as a last resort**
- **The use of a small size cylinder is preferred and more cost effective**

Lecture bottle

Cylinder

Additional rules pertaining to gas cylinders

If a faulty valve is discovered upon installation:

- **Return cylinder to shipping**
- **Label cylinder indicating it has a "Defective Valve"**

***Immediately* Inform personnel in the purchasing group - and assist in contacting the vendor as needed**

Never:

- **Permit cylinders to become part of an electrical circuit**
- **Contaminate cylinder valves with oil, grease, organic materials, or other combustible substances, particularly oxygen**
- **Transport a gas cylinder in your car**
- **Use wrenches on a valve that is equipped with a hand-wheel**

PPE

Always don the proper Personal Protective Equipment (PPE) before working with Compressed Gasses

- Mechanical safety eyewear is required when handling compressed gas systems
- Wear leather gloves and safety footwear when transporting cylinders
- Other site-specific PPE requirements must be adhered to ; e.g. hearing protection, face shields, cryogenic gloves
- Contact a Safety Officer to conduct a job hazard analysis and review procedures for new or altered activities and processes.

If uncertain, review PPE requirements with the work area supervisor

This equipment was found in service at LLE in 2008 and contributed to a severe accident

What's wrong with this picture?!

- **Incompatible low pressure regulator adapted to high pressure gas bottle using hardware store fittings**
- **Bronze pipe nipple threaded onto CGA connection**
- **Leaking regulator wrapped in electrical tape**

Never connect anything to a gas cylinder except the appropriate and approved regulator

Summary

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You must complete the M_002 Compressed Gas safety quiz to satisfy your training requirement