



Safely Working with Compressed Gases

Safely Working with Compressed Gases / Presented by Argo, an Air Liquide company

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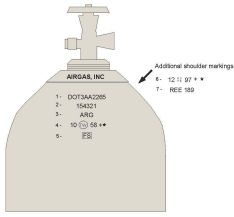
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The Cylinder

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The Cylinder



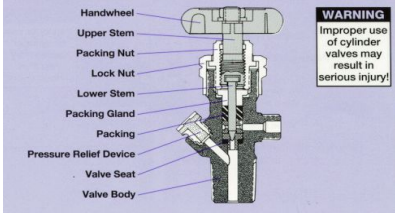
- Typically made of steel
 - Some other materials are used
- DOT regulates how cylinders are made and tested
 - Thickness of steel, composition of steel, etc
- Markings on a cylinder
 - Used by gas supplier
 - Do not tamper with
- High Pressure vs. Low Pressure



Safety when Working with Compressed Gases (Presented by Argus, an Air Liquide company)

Compressed Gas Cylinder Valve

Packed Valve (handwheel operated)



WARNING
Improper use of cylinder valves may result in serious injury!



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Pressure Relief Devices

Designed to prevent over-pressurization and failure of a cylinder

May activate and release entire contents, or may be of a reseatable type that will close when the cylinder pressure drops (propane, VGLs)

Present leak points in addition to the valve

Types of Pressure Relief Devices (PRD)

- Acetylene (fusible plugs)
- Propane (spring loaded safety)
- Rupture Disk (small piece of metal that will burst at a certain pressure)

Do not tamper with these devices!



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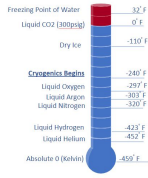
Cryogenic Liquids

Cryogenic Liquids: A branch of engineering dealing with the production and effect of very low temperatures.

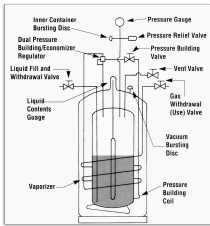
- Temperatures colder than -240° F (B.P. less than -130° F)

Vertical Gaseous Liquids (VGLs or Liquid Cylinders)

- One VGL = 18 high pressure cylinders
- A pressurized, double-walled, insulated container used to hold either cryogenic liquefied gas or refrigerated liquefied gas. A vessel within a vessel similar to a thermos.
- It is designed to maintain the temperature of whatever is inside.
- Normal Evaporation Rate (NER)
 - 1-2% loss per day



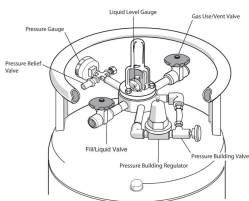
How Does a VGL Work?



- One cup of liquid Nitrogen equals 696 cups of gaseous Nitrogen
 - Pressure Relief Devices installed on all VGLs and is a normal operation of the VGL
- Can withdraw liquid or gas from these containers depending on the application
 - Pressure Builder Valve (make sure to turn off)
 - Do not adjust pressure builder regulator
- These should be handled with a liquid cylinder cart or mechanical means at all times



VGL/Liquid Cylinders



DANGER

COMPRESSED GAS



NON-FLAMMABLE
GAS
2



OXIDIZER
5.1










• NO SMOKING OR OPEN FLAMES
 • NO OIL OR GREASE
 • NO COMBUSTIBLE MATERIAL
 WITHIN 50 FEET
 • AUTHORIZED PERSONNEL ONLY

The Hazards


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Families of Gases		Examples
Oxidizing		Gases facilitating and supporting combustion but which do not burn Oxygen Nitrous oxide Ozone
Flammable		Gases that can burn only in the presence of oxidizers (air, oxygen) Acetylene Hydrogen Propane
Inert or Neutral		- Do not support life - Do not support combustion - Non flammables Nitrogen Helium Carbon dioxide
Toxic		Poisonous above a certain concentration level, according to the length of exposure Ammonia Chlorine Carbon monoxide
Corrosive		Chemical attack of many substances including metals, clothing, skin tissue, etc. Ammonia Chlorine Sulfur dioxide


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Hazards linked to gas


Asphyxia




Over-pressure




Cryogenic & chemical burns




Fire




Explosions



Toxicity



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The Basics

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Personal Protective Equipment

For handling compressed gas:

1. **Steel Toe Boots**
 - a. Metatarsal Guards are preferred
2. **Safety Glasses**
3. **Gloves**

For Cryogenic Liquid:

1. **All of the same for compressed gas**
2. **Cryogenic Gloves**
3. **Long Sleeve Shirt**
4. **Face Shield**



*Note - PPE required varies based on the gas being used. This is a generic list of PPE for all cylinders.

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General Precautions Regarding Cylinders

- **DO NOT use cylinders as rollers, supports, or anything other than to hold the contents.**
- **DO NOT place containers where they might become part of an electrical circuit.**
 - Do not ground the cylinders or use the cylinders for grounding when used for welding
 - Often see cylinders with arc burns on them
- **DO NOT expose cylinders to high temperatures**
 - Increase temperature = increase pressure
 - Do not allow to exceed 125° F
- **DO NOT expose cylinders to extremely cold temperatures**
- **Compressed gas streams should not be directed toward any person unless directed through equipment designed for personal use.**
- **The only method to identify the contents of the cylinder is by the label! If there is no label, contact the gas supplier.**

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Valve Protection Caps/Valve Outlet Caps and Plugs

- Valve protection caps for cylinders designed to accept a cap shall always be in place and hand-tight except when these cylinders are in process or connected for use.
- Coarse thread vs fine thread
- Inserting tools such as screwdrivers that are not designed for the removal of valve protection caps through the vent hole can lead to valve damage or the inadvertent activation of the valve and the release of cylinder contents.
 - Do not spray lubricating oil (due to Oxygen potential)
- Gas-tight outlet caps and/or plugs shall be in place at all times
 - 49 CFR 173.40 and are mandatory for toxic gas containers but also are permitted to be used for other products.



Leaking Cylinders

If containers have leaking or defective components such as the valve(s), caps, seals, PRDs, cylinders, etc., contact the gas supplier immediately. Do not ship these containers unless authorized by the gas supplier. When a container or valve is noticeably corroded, dented, cut, damaged or involved in an accident such as dropping, being struck, etc., notify the gas supplier and follow the provided instructions.

- How to Identify a Leak:**
- **Using your senses from a distance!**
 - Smell/Odor
 - Sound
 - Sight
 - Vapor Cloud
 - **Exercise Caution!**
 - Toxic, corrosive, flammable, oxygen deficient atmospheres may be present
 - **Contact your gas supplier immediately!**





Cylinder Storage

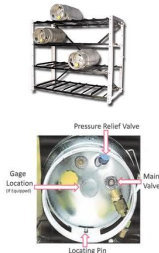
Cylinder Storage Basics

- Keep your cylinders upright and secured with a chain or another type of fastener such as a bench or wall clamp.
- Cylinders without permanent valve protection **MUST** have cylinder valve protection caps firmly in place.
- Store full and empty cylinders in separate zones/areas.
- Store cryogenic products in well-ventilated areas, free from vehicle traffic and protected from physical damage due to striking or falling objects.
- Well ventilated and well lit
- Ensure that containers stored or used in public areas are protected against tampering and damage.



Cylinder Storage Basics

- Liquefied compressed gas cylinders shall always be stored with the PRD in direct communication with the vapor space of the cylinder.**
 - Note: there are liquefied flammable compressed gas cylinders designed to be stored in the horizontal position with the PRD in direct communication with the vapor phase (forklift propane cylinders)
- Cryogenic liquid containers shall always be stored upright.**
- Do not expose to flammable liquids, salts, corrosive chemicals/fumes**
 - To prevent bottom corrosion, avoid prolonged exposure to a wet environment such as mud or standing water.
- The container valve shall be kept closed at all times (charged or empty) except when the container is in use.**
 - Never attempt to open a damaged valve.



Flammable Gases



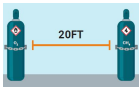
Outdoor Storage

- Stored away from oxidizers, open flames, sparks, other sources of heat and ignition
- LPG - limit storage to less than 22,500 lbs (200,000 SCF)**
 - Separate storage areas by 20 ft or fire barrier w/o openings (2-hour fire resistance) that interrupts the line of sight between storage areas
 - Cautious of OSHA PSM or EPA RMP quantities
- Separation between LPG and Acetylene if > 1,000 lbs LPG**
- Fire extinguishers within 50 feet of storage (18 lb B:C rating)**
- NFPA 55 and/or NFPA 58 have additional requirements**
 - Distances to exposures

Indoor Storage

- Quantity limitations apply (OSHA, NFPA 55 & 58)**
 - May require separate room or compartment depending on amount being stored

Oxidizer & Corrosive/Toxic Storage



Oxidizer Storage

- Oxidizers shall be stored separately from flammable gas containers or combustible materials especially oil or grease. Separation can be achieved by either:
 - A distance of 20 ft or
 - A noncombustible barrier at least 5 ft tall having a fire resistance rating of at least 30 minutes is a minimum requirement.



Corrosive/Toxic Storage

- Storage of corrosive and toxic gases shall be in accordance with local and/or provincial/territorial building and fire prevention codes (and NFPA 55)
- May want to consider using a gas cabinet for storage
- Limit quantity on site to only what is needed
 - Order on a Just In Time basis

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Cylinder Handling



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Safely Cylinder Handling



- Know your route
- Never lift or carry a compressed gas cylinder by the valve, valve protection cap, or with a magnet.
- Ropes, chains, or slings shall not be used to lift or suspend containers, unless the container was originally designed with lifting attachments.
 - Cradles or VGLs
- Always handle vertically (never roll on ground)!
- A hand truck or cart designed for cylinders, forklift truck, cylinder pallet system, or similar material-handling device should be used with the container secured to the device.
- Liquid cylinders (VGLs) shall be moved using a four wheel hand truck or power handling equipment designed for this purpose.

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Using Cylinders

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Before Using Cylinders

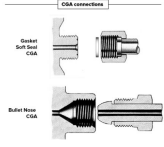
- Check the cylinder label, read and understand the accompanying Safety Data Sheet (SDS)
- Secure the cylinder before removing the valve protection cap.
- If your cylinder cap is stuck, never insert an object into the valve cap to try to loosen it. Use an appropriate cylinder cap wrench to safely remove the cap or return the cylinder to your supplier.
- Ensure that all flexible lines and tubing are fastened securely.
- Inspect the cylinder valve for damaged threads, dirt, oil, grease, etc., and remove any dust or dirt with a clean cloth
- Check that regulators, hose and fittings are properly maintained and compatible with the gas cylinder to be used.

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Connecting Cylinders

- Excessive force shall not be used when connecting containers.
 - Container valve connections that do not fit shall not be forced.
- Threads on regulator connections or other auxiliary equipment shall match those on the container valve outlet.
 - RH vs. LH Threads
- The valve outlet connection should conform to recognized standards such as CGA V-1 (Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections).
 - Use of adapters that can change the container's CGA connection from one product to another shall not be permitted by users. Same-product-to-same-product reducers are not covered by this paragraph. Adapters used in medical service can have additional requirements.



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Opening the Valve

When opening a cylinder:

- Stand aside (not in the line of fire)
- Open cylinder valves slowly
 - Especially important with Oxygen
 - Contact the gas supplier if the valve is difficult to operate.
 - On valves without handwheels such as a wrench-operated valve use the wrenches provided or recommended by the gas supplier. Container valves can be damaged by overtightening.
- Test for leaks with leak detector solution
 - Never use a leaking cylinder
 - Or perform static leak check
- Never tighten a connection under pressure



28

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Oxygen & Acetylene



29

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Acetylene

- Unstable in pure form
- Filled with a porous mass
 - Hard sponge with very small pores
 - Heat from decomposed Acetylene is absorbed by this gas which limits the chain reaction
- Acetylene gas is dissolved in Acetone (or Dimethylformamide/DMF)
 - Helps stabilize Acetylene by inhibiting the decomposition reaction
 - Allows cylinder to hold 8x more gas
- Contains a fusible plug as a pressure relief device
- DO NOT OPERATE above 15 PSIG!
- Withdrawal Rate
 - Preferably only open $\frac{3}{4}$ of a turn
- LEL (2.5%), UEL (83%)

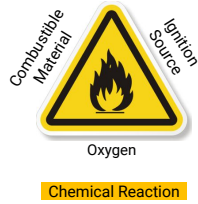


30

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Oxygen Characteristics

- Oxygen is NOT flammable – however it does support and can greatly accelerate combustion. Because of this, precautions need to be taken to help prevent dangerous situations.
- As the oxygen concentration in air increases, the potential fire risk increases and the fire propagation rate increases.
- At oxygen concentrations above 23.5% in air, the situation becomes dangerous due to the increased fire hazard.
- Most materials burn aggressively, sometimes explosively in oxygen, even materials that don't normally or readily burn in air.



31

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Oxygen Hazards

Adiabatic Compression

- **Adiabatic** = Occurring without gain or loss of heat.
 - Rapid increase in gas pressure adiabatically heats the oxygen gas.
 - As the gas flows through a small orifice or hits a dead end, the increased heat can lead to fire or detonation if there is a presence of fuel & oxygen
- To minimize the risk, we need to open valves SLOWLY & ensure that our pipes and components are oxygen-compatible materials that are clean of any hydrocarbons or oils.

Oxygen Clean!

- Contamination can lead to dangerous fires in Oxygen systems
 - Small particulates
 - Hydrocarbon based material (solvents, degreasers, oils, greases, lotions, etc)
- Even contamination on gloves or on clothing could lead to a potential fire if contacted by Oxygen

32

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Oxygen Systems: Safe Operating Best Practices

- No smoking, wear the appropriate PPE, and use oxygen gas monitors when needed.
- Stay behind barriers when the oxygen system is operating.
- Prevent leaks and keep o-ring's / gaskets in good condition.
- Keep system clean and prevent contamination.
- Open valves and pressure controllers SLOWLY and stay on the upstream side of the system (stay out of the line-of-fire).
- Avoid shocks to the oxygen system.
- Use only suitable and approved equipment and spare parts.
- Use vehicles that have adequate ventilation for transport of cylinders and liquid cylinders.
- When clothing has become saturated with oxygen, personnel shall be removed from the oxygen source and from potential ignition sources and should either change their clothing or ventilate their clothes in a normal atmosphere for not less than 15 minutes by removing their outerwear and moving their arms and legs

**CAUTION
OPEN VALVE
SLOWLY**

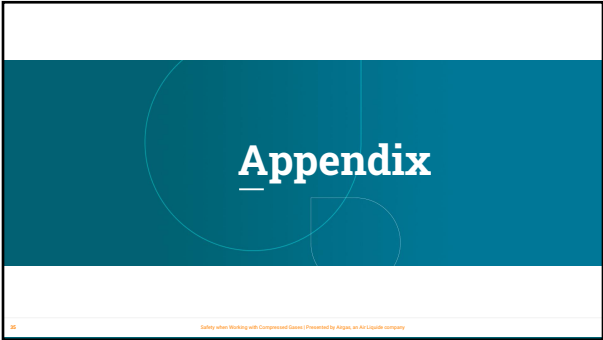
Specific to Liquid Oxygen systems:

- Never run pumps dry, cool them down before start, and don't bypass safety devices.
- Address any excessive icing on cryogenic equipment.
- Prevent cryogenic embrittlement of carbon steel (Low Temperature Protection)

33

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Key Regulatory Agencies

- PHMSA (Pipeline and Hazardous Materials Safety Administration)**
 - Regulates transport of compressed gases, cryogenic liquids, etc by highway
 - Special Permits
- OSHA**
 - Various standards associated with use, storage, and handling of compressed gases/cryogenic liquids
- CGA (Compressed Gas Association)**
 - Produces multiple safety documents associated with filling, handling, storing compressed gases/cryogenic liquids
- NFPA (National Fire Protection Association)**
 - Establishes codes and standards

26

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Additional Reference Information

OSHA

- **1910.101: Compressed Gases (general requirements)**
 - ***Note - this actually incorporates all of CGA P-1 into regulation by reference
- **1910.102: Acetylene**
- **1910.103: Hydrogen**
- **1910.104: Oxygen**
- **1910.105: Nitrous Oxide**
- **1910.253: Oxygen-fuel gas welding & cutting**
- **1926.350 - Gas welding and cutting**

Self Inspection Checklist (CDC & OSHA)

- [Checklist](#)

Additional Reference Information

NFPA

- **NFPA 55: Compressed Gases & Cryogenic Fluids Code**
- **NFPA 58: Liquefied Petroleum Gas Code**
- **NFPA 99: Health Care Facilities Code**

CGA

- **CGA P-1: Standard for Safe Handling of Compressed Gases in Containers**
- **CGA P-12: Guideline for Safe Handling of Cryogenic and Refrigerated Liquids**
- **CGA P-61: Ergonomic Guidelines for Industrial and Medical Gas Industry**
- **CGA P-83: Guidelines for Cleaning Externally Contaminated Medical Gas Cylinders**
- **CGA P-71: Standard for Safe Movement of Portable Cylinder Banks**
