



Common Compressed Gas Emergency Response

June 2022

Compressed gas is a chemical in a cylinder with the added hazards of pressure or low temperature



Compressed gases have many different hazards. Many have multiple hazards

Pressure	Oxidizer
Extreme Cold	Water Reactive
Health	Asphyxiant
Toxic	Explosive
Corrosive	Self Reacting
Flammable	
Reactive	

Common Compressed Gases

- Acetylene
- Ammonia
- Butane
- Carbon Dioxide (Compressed Gas & Refrigerated Liquid)
- Chlorine
- Nitrogen (Compressed Gas & Cryogenic Liquid)
- Nitrous Oxide (Compressed Gas & Refrigerated Liquid)
- Oxygen (Compressed Gas & Cryogenic Liquid)
- Propane
- Sulfur Hexafluoride

Liquid oxygen is extremely reactive when spilled onto asphalt. Impact from dropped tool can ignite it. Extent of oxygen cloud is beyond the mist (condensed water vapor). Rule of thumb for HazMat is to wait 30 minutes after all frosting is gone.



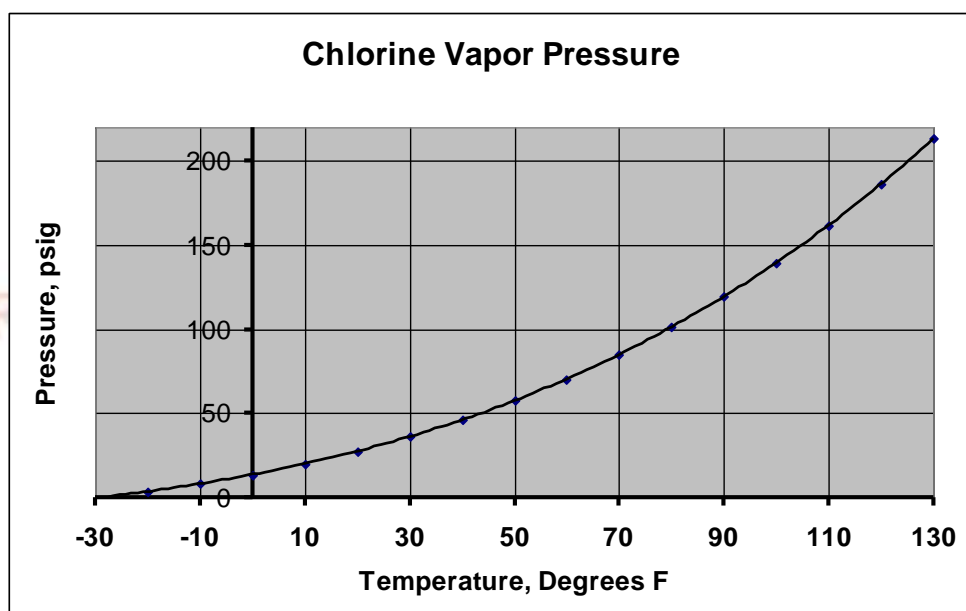
Over 200 different gases are packaged in cylinders plus many gas mixtures

Non liquefied gas (nitrogen, hydrogen). A gas with a critical temperature below ambient. Will always remain a gas regardless of pressure. Defined as any gas with boiling point $> -130^{\circ}\text{F}$ ($> -90^{\circ}\text{C}$) pressure is used to determine contents of cylinder

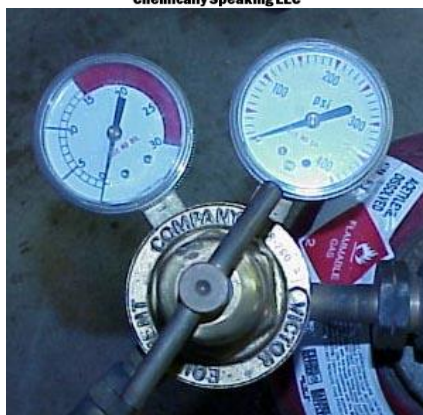
Liquefied gas (propane, carbon dioxide). Is a gas with a critical temperature above ambient ($> 70^{\circ}\text{F}$). Will liquefy at its' vapor pressure. Defined as any gas with boiling point between -130°F (-90°C) and 68°F (20°C). Weight used to determine contents of cylinder.

Liquefied gases will maintain the vapor pressure as long as there is liquid in the cylinder

Vapor pressure of liquefied gas varies with temperature



It is a liquefied gas but because of its instability, it is packaged as a dissolved gas. The decomposition reaction of C_2H_2 is highly exothermic and can cause more molecules to decompose (self sustaining reaction) US safety rules prohibit it from a use pressure above 15 psig



Acetylene cylinders are filled with a solid material which absorbs acetone or DMF. Acetylene is dissolved in the acetone or DMF. The solid acts as a flash arrestor to quench a decomposition reaction.

DMF is the preferred solvent because of the lower vapor pressure and higher flash point. For high purity use some companies are shipping in cylinders without a solvent

UN 1001 acetylene, dissolved

UN 3374 acetylene, solvent free

Propane

Most widely used consumer gas

Flammable liquefied compressed gas with a vapor pressure of 110 psig @70°F

Heavier than air, vapor specific gravity of 1.52

Consumer propane is odorized with ethyl mercaptan

20 lb Cylinder

Designed to 4BA (178.51) Specifications with a 240 psig working pressure

Welded Carbon Steel

A spring loaded pressure relief device (PRD) which will relieve excess pressure caused by fire and reset.

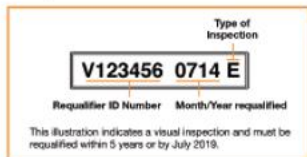
A cylinder can have a water capacity of 47.1 - 47.6 lbs. It can be filled up to 20 lbs of Propane (49CFR173.304}

Blue Rhino and Amerigas prefilled cylinders have 15-16 lbs

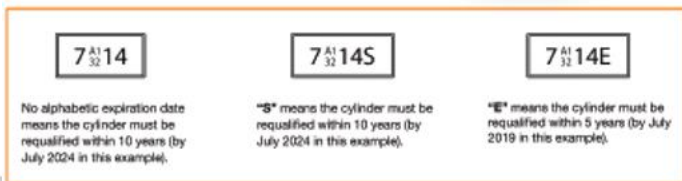


Propane cylinders must be periodically requalified to be safe for use*. Do not use cylinders that have not been requalified because you risk property damage, severe injuries, or death. To see if your cylinder is okay to use, look for these markings:

- A Manufacturing Date:**
Cylinders must be requalified within 10 years of manufacture (in this illustration by May 2015).
- B Requalification Date:**
If the cylinder is older than 10 years, look for a "requalification date."



Other possible requalification markings:



- Visual inspection
E is 5 years
- Pressure Proof Test S is 10 years (was 7)
- Volumetric expansion is 10 years (was 12)
- Change due to food truck explosion in Philadelphia

Overfill Protection Device (OPD) Triangular handle.

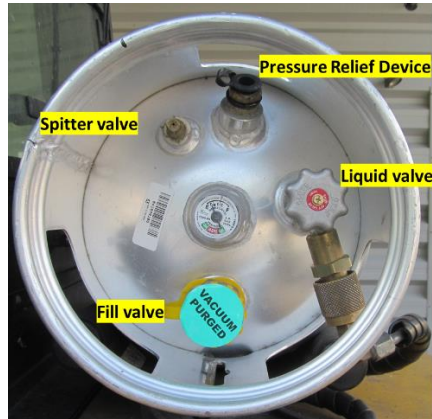
Used for consumer propane cylinders up to 40 lbs.

- vapor service outlet
- relief valve
- overfill prevention device
- CGA 791 Connection
- Right handed connection
- Hand tight

A check valve prevents propane from flowing out if the valve is opened when it is not connected to a system.

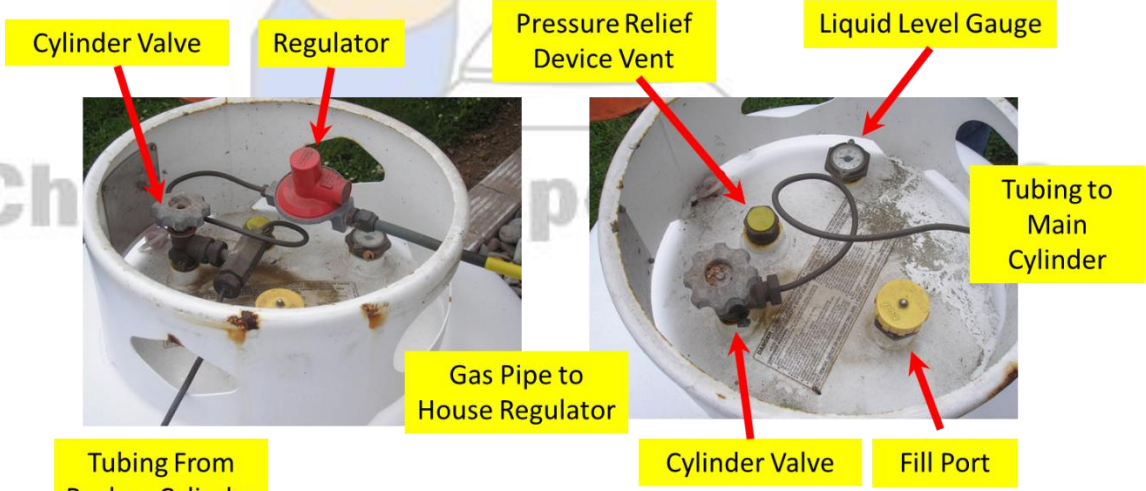
Excess flow valve to stop flow if hose fails

Spitter valve is used to determine when cylinder full of propane when not filling on a scale.



Forklift Cylinder (33 lbs)

House propane systems
Typically 1000 lb cylinders
Filled by truck



Main Cylinder

Backup Cylinder



In a fully engulfing fire a propane cylinder can BLEVE due to liquid expansion and weakening of carbon steel sidewall. It can take 5 or more minutes to do so. Aluminum will weaken faster.

Exploding cylinders become incendiary devices that fly hundreds of feet and can involve other structures. Flammable gas facility fires have become fully involved in minutes as adjacent cylinders become involved.

Composite cylinder will not BLEVE. They will vent through the walls when the resin burns and chars

Composite LPG Cylinder Test Burns: No BLEVE Damage Not As Catastrophic as Steel Tanks

Assistant Chief Denis Murphy & Deputy Chief Gene Pietzak
Nassau County, NY, Fire Service Academy

Slideshow Images:

- [Composite LPG Cylinder Test Burn](#)

Recently, the Nassau County Fire Academy in New York conducted live fire tests on the new lightweight fiberglass composite LPG (propane) cylinders that are now available for sale to the public in the New York area. Present at the testing were members from the Nassau County Fire Academy, Nassau County Fire Marshals and Suffolk County Fire Academy.



Courtesy of Nassau County Fire Academy
Photo 1: The 20-pound composite cylinder was filled to its normal capacity of 80 percent with liquid propane for the tests.



EMERGENCY RECALL ORDER

The Pipeline and Hazardous Materials Safety Administration issued an emergency recall of 55,000+ propane cylinders manufactured by The Lite Cylinder Company.

These cylinders may leak flammable gas or suddenly rupture.

The full recall order is available at: <http://go.usa.gov/bbyV>



The affected cylinders may be marked in the location indicated above with any of the following numbers: M5729, DOT-SP 14562, DOT-SP 13957, DOT-SP 13105 (copy of recall order). Cylinders manufactured by Composite Cylinders (M0408) and marked with this number are not subject to the recall.

Oxygen

Oxygen is the second largest consumer compressed gas in use

A gas compressed to high pressures (>2000 psig) in a cylinder or as a very cold liquid, -297°F (cryogenic) in a dewar

Becoming more common

Liquid Oxygen Home breathers

Fish Trucks & Ponds

Oxygen Bars

Hyperbaric Chambers (improves injury healing)

Oxygen Hazards

Is slightly heavier than air, vapor specific gravity 1.10

Pure oxygen can be very reactive

Systems must be properly designed, cleaned, maintained and operated (Use no oil, Oxygen Cleaned)

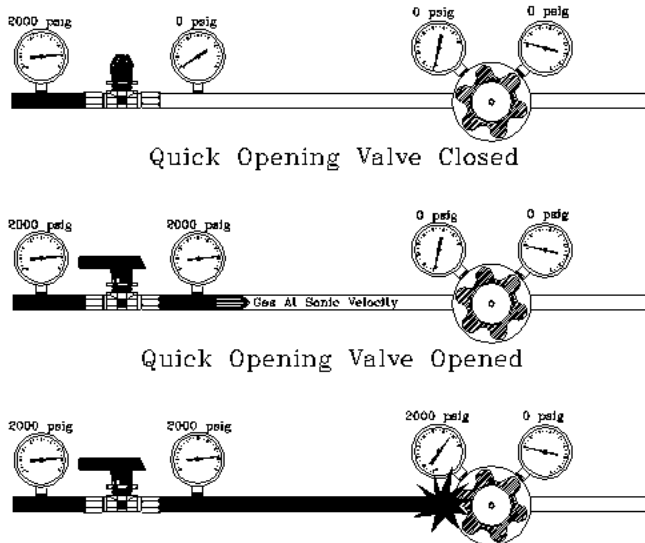
Explosions or fires can be initiated by the sudden pressure increase when a cylinder valve is opened if the system is not cleaned or maintained properly.



Mixed with a flammable gas (hydrogen, propane) will become explosive. In welding operation this can happen if there are no backflow preventers

Adiabatic compression

Adiabatic compression occurs every time a cylinder valve of a high pressure gas cylinder is opened and gas flows into the low pressure downstream piping, rapidly pressurizing that system. Adiabatic compression occurs because the pressurization of the gas occurs so rapidly that there is no time for the heat of compression to dissipate into the surrounding piping and valves. This rapid compression of the gas generates elevated temperatures that will can ignite a flammable material or dissociate a gas like NF_3



Temperature Increase From Sudden Compression		
psig	Temp F	Temp C
100	453	234
1000	1303	706
2000	1688	920
4000	2158	1181

High Velocity Oxygen Impacting Closed Regulator
 Improper cleaned or maintained regulators have exploded
 Aluminum and carbon steel are the worst metals for oxygen service. Will burn at a pressure as low as 15-25 psig. Brass is the preferred metal for a pressure regulator

Medical E aluminum regulator recall due to numerous fires (1994-2000)

Flow friction ignition due to reuse of plastic crush gasket

Oxygen enrichment is at 23.5% or higher. Flammable materials will burn faster or ignite quicker.

Medical Oxygen

- Compressed gas (high pressure cylinder)
- Liquid oxygen (cryogenic liquid)
- Concentrator (concentrates oxygen from air)
- Numerous incidents due to patient smoking while using medical oxygen



Medical E oxygen cylinder is typically aluminum

Aluminum cylinders ruptured in 5 minutes versus the 10 minutes of steel in a fire

Gas Supply Systems at Medical Facilities must have a 24 hr backup supply, NFPA55 8.5.1.4

Medical gases have a color code. Oxygen is green

Liquid Oxygen is the most cost effective method of keeping large numbers of fish alive while transporting them in trucks. This is particularly true when transporting large fish such as market size catfish (1.5 to 3 lbs each) over long distances. The Oxygen is stored as a liquid in a dewar (tank) which may hold 4,500 cubic feet of oxygen and weigh close to 800 lbs

Dewar

A pressurized, double-walled, insulated container used to hold either a cryogenic liquefied gas or refrigerated liquefied gas. (large thermos bottle)

If gas is not used, pressure will build until it is released by a spring loaded relief valve

The typical liquid loss is about 2.3% per day

Nitrous Oxide

A liquefied gas with a vapor pressure of 735 psig in a cylinder or refrigerated liquid, -127°F in a dewar

Most common use is as anesthetic or race cars

Can be unstable under certain conditions. Similar to acetylene, it can decompose exothermically.

Nitrous oxide is manufactured using ammonium nitrate

Substance abuse is problem

Acetylene

Acetylene is a flammable compressed gas

Lighter than air, vapor specific gravity of 0.91

Liquid acetylene is shock sensitive

Welded carbon steel cylinder DOT 8 or 8AL specification filled with a solid



PRD usually found on neck and or bottom of cylinder CGA CG- 3 which consists of a fusible plug with a nominal yield temperature of 212°F (100°C). Sometimes in valve body



In a fire an acetylene cylinder can

- PRD melts and vents with a large jet flame

- PRD melts and the gas accumulates in the ceiling area. It can deflagrate or detonate

- Cylinder ruptures during the fire

- A reaction in the cylinder is initiated and if not extinguished could rupture the cylinder

Due to previous incidents, the Europeans have a strict protocol for acetylene cylinders in after a fire.

- Formerly it was evacuate 200 m for 24 hours

- Based on testing by BAM (see right) and discussions with fire experts, 1 hour of cooling followed by 1 hour of monitoring is sufficient

- Cylinder must have reflective tape

- Users must use flashback arrestors and do a comprehensive risk analysis

Acetylene is <10% of the (0.018 mj) Ignition Energy of Other Hydrocarbons (0.25 mj)

- Almost 38,000 times that of Ammonia (680 mj)!

Acetylene has a very wide flammable Range (2.5% - 80%/100%) While ammonia has the smallest (16%-25%)

Older acetylene cylinders were filled with asbestos

Acetylene trailers have cylinders manifolded together to provide a fill supply at a welding gas filling facility or at use site. Named Mobile Acetylene Trailers (MATs)



Ethylene

Ethylene gas triggers ripening of climacteric fruit, such as tomatoes, apples, and bananas. Ethylene is such a powerful hormone that if a single banana is ripening in transit from the tropics, the gas can spur a mutiny of ripening among the rest.

Ripening process is 0.1%, LFL of ethylene is 2.7%

Hydrogen

As a gas compressed to high pressures (>2000 psig) in a cylinder or as a very cold liquid, -423°F (cryogenic) in a dewar

Is much lighter than air, vapor specific gravity 0.07

Wide flammable range (4%-76%)

Low ignition energy (0.017 mj)

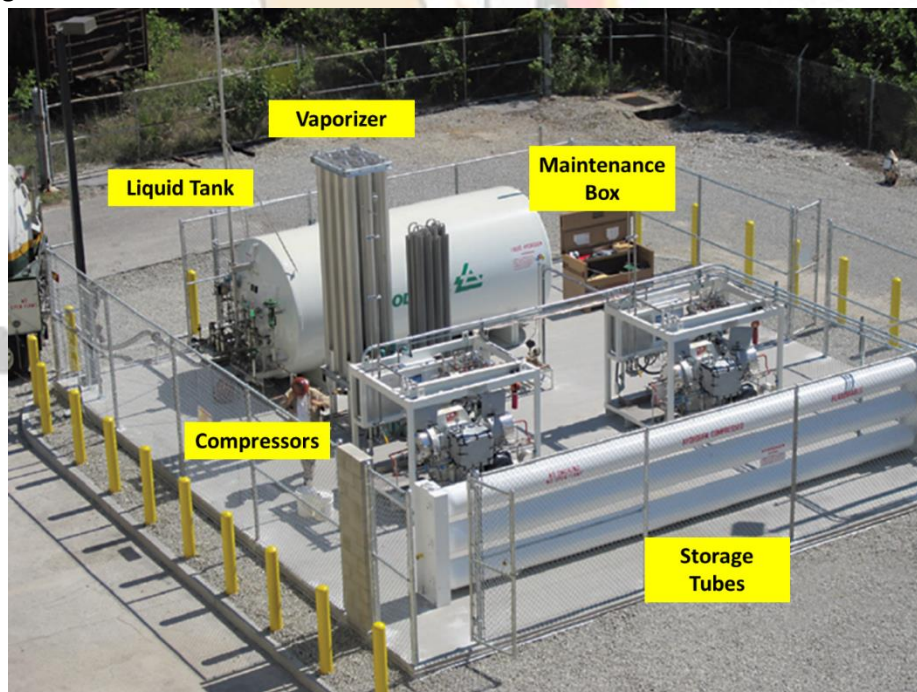
High pressure releases almost always ignited

Flame is invisible

A hydrogen fuel cell generates electricity through an electrochemical reaction using hydrogen and oxygen. This is used for cars

Motor vehicles, 6,000 – 16,000 psig

Typical fueling station



Forklifts, advantage is constant power and exhaust is only water vapor



Fuel cells are used as backup power for cellphone towers. 4-16 cylinder pack of hydrogen. A 16 cylinder pack can supply 281 hr (11.7 days) of power at 1 kwh



Metal hydride absorbs hydrogen, lowering the pressure in the cylinder

Ammonia

Liquefied Gas, 114 psig vapor pressure @70°F

Lighter than air, vapor specific gravity of 0.59

Corrosive, Alkaline

Will react with brass, zinc

Highly soluble in water

Flammable at high concentrations and in very narrow range

Vapor is visible in concentrations of 6-10,000 ppm



Flammable in concentrations of <13% in air or has a flammability range wider than 12% regardless of lower flammability concentration. May not identify some gases which are flammable under certain conditions

Increasing use for refrigeration. Large systems can be over 100,000 lb charge

Theft for PCP manufacturing is a problem. 20 lb propane cylinders are sometimes used. The brass valve is embrittled. Blue green discoloration



Carbon Dioxide

Liquefied gas, 838 psig vapor pressure @70°F, dry ice or refrigerated liquid

Inert, simple asphyxiant

Slightly soluble in water forming carbonic acid

Carbonation of beverages using refrigerated carbon dioxide in refillable dewars is increasing



Water well sanitation using carbonic acid

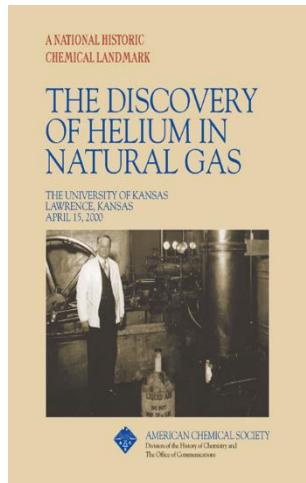
Carbonic acid can corrode carbon steel cylinders. Aluminum cylinders are used or a residual check valve to prevent backflow of water into carbon steel cylinders

Helium

During a Dexter, Kansas celebration of a recently discovered gas well they tried igniting the gas but no ignition



15% CH₄, 72% N₂ and 12% Inert (1.84% He)



Helium was discovered on Sun by British Astronomer, J. Norman Lockyer and named for Greek word for Sun, Helios

Formed from radioactive decay of heavy elements

A rich stream of natural gas has 0.2%

In 1915 only 1 cu. ft. of Helium existed

In 1927 the Macy's parade had their first Helium balloons (Felix the Cat)



Until 1996 was controlled by US as strategic material

Highest heat transfer of any gas

Liquid is coldest temperature 4.2 K (-268.9 C)

Goodyear Blimp requires 247,800 cu. ft. (826 cyls!)

Space Shuttle used 7,500,000 cu. ft. each flight

Shortage of supply worldwide.